"The Impact of News on Expectation Formation in Monetary Policy, Business Cycles and Inflation Forecasts"

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CHAPTER 1

Introduction

1.1 General Remarks

Contemporary macroeconomics recognize the vital importance of expectations. Expectations are a basic building block of economic theories. While there have been earlier attempts emphasizing the role of expectations, the first to give due weight on it in a macroeconomic context was John Maynard Keynes (1936) in his General Theory. He stresses their importance without referring to a specific modelling. In the 50s and 60s expectations were introduced in all fields of macroeconomics, mostly based on static concepts or adaptive expectations. Rational expectations were pioneered in the seminal work of Robert E. Lucas Jr. and Thomas J. Sargent in the early 1970s. Beginning with Friedman's (1979) criticism of the unspecified nature of the expectations formation mechanism in rational expectations models, there is a growing literature in modelling how agents update their expectations when news arrive. Lately, there has been more refinements with respect to processing capabilities and informational restrictions of agents.

The key question nowadays is how new information is incorporated into beliefs and economic decision making. In the following we will briefly survey several modelling attempts and lines of thinking.

The present "industry standard", the New Keynesian approach, is based on the Calvo pricing rule. According to this rule, only a specific share of firms can adjust their prices at each point in time (price stickiness). However, over the last decade criticism has intensified, challenging some key assumptions underlying this approach. One major concern is that physical costs for changing prices are low in most sectors. Furthermore, the New Keynesian approach does not match the observed empirical patterns or delivers even inconsistencies. For instance, it predicts that deflation increases output, whereas we usually observe a depression during deflation phases. The most prominent challenger of Calvo pricing is the concept of sticky information. Mankiw and Reis (2002) replace the staggered pricing model of Calvo (1983), which is employed extensively in Woodford (2003), with a model of staggered information flows. Mankiw and Reis (2002, 2006) argue that agents update their information occasionally rather than instantaneously, resolving considerable puzzles in the persistence of inflation. In every period, each firm has a constant probability of updating its information set. Firms which can update their information set can also choose their prices optimally. The remaining firms are also free to set prices. However, they do not update their information from the previous period. Sims (1998, 2003) pursues a slightly different way allowing for a micro-foundation of the argument. He argues that the delay is due to convex costs in processing all types of information and calls this rational inattentiveness. To put it differently, people observe all information but have to a certain extent limited capabilities in processing the information. Reis (2006) discusses the inattentiveness of producers facing the costs of acquiring, absorbing and processing information. Finally, recent developments discuss so-called endogenous inattentiveness (Branch et al., 2007), or combine issues of sticky prices and sticky information. For instance, Klenow and Willis (2006) present a simulation in which both relationships are modelled and suggest that price changes are not due to old information. Dupor et al. (2006) address the question concerning the exclusiveness of sticky information or sticky prices in a similar way and find evidence for both. Recently there have been attempts to incorporate inattentiveness in general equilibrium models.

The ideas and concepts derived above have direct implications for monetary policy. Over the last decade communication has become an important tool to guide markets and anchor inflation expectations. Works like for instance by Cukierman and Meltzer (1986) highlight its relevance. Notably, recent attempts point out that sharing as much information as possible with the public is not necessarily welfare enhancing. Morris and Shin (2002) stress that too much information may reduce the incentives for the public to gather information even if they have a comparative advantage in doing so and in turn leads to inefficient outcomes. Others like Kahneman (2003) put

forth that limited capabilities in digesting information might consequently lead to misunderstanding and increased volatility in financial markets.

Turning to the business cycle literature, we can report that the awareness of news affecting the expectations and thereby driving fluctuations has increased in recent years. Although already addressed at the beginning of the century (Pigou, 1927), it has been a considerable challenge to incorporate those ideas into standard business cycle models. Only recently Jaimovich and Rebelo (2006) have successfully shown that good news about expected total factor productivity lead to an expansion today. Focusing on business cycle comovement, Veldkamp and Wolfers (2007) propose a model arguing that the observed excess comovement may be driven by strategic complementarities in information acquisition. Due to relatively low marginal cost of replicating information on the whole economy (as compared to sector-specific information), the impact of common shocks relative to sector specific shocks is amplified.

While the general debate as well as recent modelling approaches incorporate different forms of adjustments of expectations to news the empirical evidence remains scant. The main reason for the apparent lack of empirical evidence lies in the challenge of measuring expectations accordingly. For instance, with respect to testing theories of price stickiness and/or information stickiness empirically, the few studies available focus exclusively on the U.S. In the paper by Mankiw et al. (2003) they analyze data from three sources. The Michigan Survey of Consumer Attitudes and Behavior surveys a cross-section of the population on their expectations for the next year. The Livingston Survey and the Survey of Professional Forecasters (SPF) covers professional analysts working in industry and professional forecasters, respectively. Mankiw et al. (2003) show that their results are inconsistent with rational or adaptive expectations approaches, but may be consistent with sticky price models.

1.2 Outline of the Thesis

This dissertation elaborates on the role of expectations in economic decision making. More specifically, we explore empirically how new information affects expectations with regards to monetary policy, business cycles and inflation forecasts.

With respect to monetary policy, announcements made by the central bank are the key source of information as they reveal the assessment of the central bank officials on the current stance of the economy and provide news on the future path of monetary policy. The first part of this

dissertation discusses the relevance and the effectiveness of announcements of the European Central Bank (ECB) on the expectation formation of market participants. These decisions are made publicly available via a press release launched at 13.45 CET and explained by the ECB's president in a press conference scheduled for 14.30 CET. Both channels are vital instruments for providing information about the short-term path of monetary policy, helping understand the way monetary policy is conducted and in turn increasing its effectiveness.[1] As market participants follow both events carefully and update expectation on future monetary policy in response to them, it is valuable to analyze how they are digested. The challenge lies in an appropriate monitoring of the key communication device, the introductory statement, and in tracking the response to it. For this purpose it is indispensable to employ suitable proxies for communication events and market expectations. We estimate the impact of surprises in the interest rate announcements via the Reuters survey of professional forecasters. For the content of the press conference we utilize the Berger-de Haan-Sturm indicator and spawn another communication indicator. Both indicators are content based and are not constructed by counting signal words. We refrain from using indicators based on signal words as there tendencies in the ECB governing council to abandon the use of them. The Berger-de Haan-Sturm indicator, however, incorporates a subjective connotation. In order to capture the expectations of market participants we employ the interest rate at different maturities (Chapter 2), the exchange rate (Chapter 3) as well as media articles (Chapter 4).

Obviously, news are an important ingredient of expectation formation in many other economic areas as well. The second part of this dissertation addresses this issue by exploring the effect of incoming information on business cycle comovement (Chapter 5) and on inflation expectation formation (Chapter 6). Our inference is based on the consideration that market participants in real life make their decisions under incomplete information. Costs or processing capabilities may limit the scope of information on the state of the economy. This forces people to take action based on information provided by cheap and readily available sources, for instance the media. In this part we will investigate to what degree these informational restrictions and complementarities affect economic outcomes. For this purpose we examine, on the one hand, whether information complementarities can be a source of business cycle comovement and, on the other hand, to which extent the catering of articles on inflation triggers updating of inflation expectations.

In the following we briefly lay out the content of each chapter. We begin our course on the effects of economic news by monitoring the impact of ECB announcements on financial markets

[1] See for instance Blinder (1998).

expectations. In Chapter 2 we investigate how interest rate announcements and the press conference affect expectations, as captured by movements in market based interest rates at different maturities. We apply the Berger-de Haan-Sturm indicator that quantifies the contents of the ECB's introductory statements and allows disentangling ECB statements on prices, the real and the monetary sector. We provide evidence that it matters *what* issue the ECB is speaking about: especially the ECB's statements on price developments represent important news to financial markets. In addition, we stress that it also counts *when* the ECB is speaking: communication has less impact when inflation is above the ECB's inflationary target of close to but below two percent. Moreover, we provide evidence that communication by the ECB has a different impact on different maturities. More specifically, it targets the medium- to long-run horizon.

While this approach enlightens the discussion in several aspects it lacks with respect to accurately identifying and tracking the effect of communication in a timely fashion. Moreover, the instruments the ECB has at its disposal may be interrelated and may be complementary to each other. In order to address this shortcomings we switch from daily to high-frequency 5-minute data focusing on the EUR-US Dollar exchange rate.

Chapter 3 investigates the impact of the ECB's monetary policy announcements on the level and volatility of the EUR-US Dollar exchange rate employing an AR-FIGARCH specification. The exchange rate is an equivalent instrument to capture market expectations. Using high-frequency data we estimate the individual and complementary effects of the release of the interest rate decision, the ECB's introductory statement and the question and answer session. This time we employ a different indicator which explicitly addresses the content without any subjective connotation incorporated. As we consider a GARCH specification we can also trace the impact of communication on the volatility of the exchange rate. We provide evidence that surprise interest rate changes explain the movements in the exchange rate immediately after press release. Our main finding is that financial markets react most strongly to communication about future price developments. In line with the predictions of Clarida and Waldman (2007), market participants seem to use the new information concerning future inflation rates to update their beliefs about the ECB's future interest rate setting. Moreover, when the previously announced interest rate decision was associated with a (negative) surprise, then the introductory statement also serves as an instrument to explain the decision to the market participants. Above that, statements on exchange rates are incorporated by markets in a similar fashion. Finally, we provide convincing evidence that the importance of the introductory statement increased considerably over the recent years. It has become a powerful tool in guiding market expectations.

The results of the preceding chapters are based on monitoring movements on market instruments. Notably, this is a very common but specific way of monitoring expectations. In Chapter 4 we investigate how the ECB guides market expectations following a distinctive path. More specifically, we test the signalling power of central bank communication relative to the key interest rate setting regarding expectations about the future interest rate decisions taken from a data set on media reports shortly after the ECB meeting comprising 01/1998–12/2004. This approach has the advantage that it catches, in contrast to market related instruments, the bottom-line of the signals as it was perceived by the media. Our results show that both signals affect expectations in the desired direction. The last interest rate decision is, however, the primary signal for the expectations on the future path of monetary policy. In addition, we provide evidence that the magnitude of the response varies if we condition on the topic communicated, interest rate surprises, the inflation rate, the sign of the interest rate change as well as market uncertainty.

Overall, the first part provides evidence that communication is an important instrument in guiding market expectations. This result holds using different proxies for expectations, different indicators and different econometric setups. Furthermore, the future outlook on price developments and inflation is the most valuable information market participants receive. Finally, there is compelling evidence that the instruments used complement each other.

As mentioned in the opening paragraph news are important ingredients in decision making in other economic areas as well. Chapter 5 answers the question to which extent information complementarities can explain excessive business cycle comovement across sectors. Veldkamp and Wolfers (2007) model an equilibrium outcome where firms have to deduct their own productivity from aggregate information. As firms observe similar information they take more similar actions and hence output is more correlated across sectors than productivity. Using German data on firm expectations and perceptions as well as a data set on media coverage, as a proxy for news, we find evidence that news influence a firm's information set. More importantly, news on aggregate developments, on average, affect firm expectations and perceptions significantly more than the coverage of sector-specific events. Finally, there is substantial heterogeneity between sectors to the response of news. This result is driven by the discrepancies in the demand of information on their own productivity. Companies with a lower correlation with the economy, higher growth rates and greater volatility have stronger incentives to invest in sector-specific information.

Chapter 6 analyzes the impact of the media on consumers' inflation expectations. We distinguish two channels through which media can influence expectations. Similar to Chapter 5 information restrictions are likely to play an important part. First, the intensity of coverage of inflation

reports plays a role. We denote this as the volume channel. This volume channel matters as more coverage eases the availability of information, triggers updating of beliefs and thereby increases the accuracy of inflation forecasts. Second, the contents of media reports are crucial. We entitle this as the tone channel. The tone channel is important as it might, on the one hand, improve the forecast. If correct information is spread, it can help to update expectations in the correct direction and thus improve the accuracy of inflation expectations. However, on the other hand, it can bias expectations, as reports might also likely exaggerate economic signals and amplify inflationary fears in order to raise circulation of the newspaper. Employing a unique data set capturing media reports dealing with price developments in Germany comprising 01/1998–12/2006 we are able to discriminate between these two effects. We find that the volume effect improves the accuracy of consumer forecasts while the tone channel induces a media bias. Moreover, those effects vary with age and education of the respondents. Older and educated people update more and are less prone to the tone bias.

From the analysis we confirm theoretical evidence and concepts of rational inattention and sticky information. People face information constraints and base their decision on edited information provided by common and easily accessible sources. As we show, this has its immediate consequences on expectation formation and economic outcomes.

Part I

Expectations and Monetary Policy

CHAPTER 2

What Matters When? The Impact of ECB Communication on Financial Market Expectations

2.1 Introduction

> *"...central banks communication should ensure that markets understand the systematic responses of monetary policy to economic developments and the current assessment of the central bank. Successful central bank communication supports predictability and correct price formation in financial markets, contributes to efficient allocation of funds and reduces uncertainty about future interest rates."*
>
> Jean-Claude Trichet (2005)

This statement by Jean-Claude Trichet is presumably a response to the earlier criticism about the public's understanding of ECB communication and reflects the relevance of this issue by the ECB itself.

This chapter is based on Lamla and Rupprecht (2006).

Over the last decade central bank communication gained rising attention. From a theoretical point of view, there is a broad consensus that communication, under certain conditions, increases the effectiveness of monetary policy.[1] This is mainly due to the fact that communication is an important instrument for a central bank to achieve more transparency and credibility (Geraats, 2005 and Woodford, 2005). However, the relationship between communication and welfare is not necessarily positively related, i.e. more communication is not always welfare enhancing. Theory also stresses that sharing *all* the information with the public may not be beneficial for a central bank to pursue its mandate either (Mishkin, 2004). Hence, an optimal design of central bank communication is still to be discovered.

Despite the practical and theoretical focus on the topic of central bank communication, empirical interest in analyzing the role of communication for monetary policy making just emerged recently. Studies such as Fratzscher (2004 and 2005), Jansen and de Haan (2005) and Jansen and de Haan (2007) analyze the impact of ECB communication on different financial market data, such as exchange rates or money market interest rates. All provide support for the theoretical predictions that communication should affect asset prices by influencing expectations.

The few studies that deal with this issue only focus on the existence of an impact of communication. In this chapter we want to go a step further. Hence, we do not only check whether there exists a relationship between ECB communication and financial markets employing better measures, but also survey the horizon over that communication influences market expectations. Moreover, we investigate whether financial markets pay particular attention to the ECB's evaluation of topics like price stability, developments in the real economy or monetary indicators separately. We analyze in this thesis throughout Chapters (1)-(3) how financial markets judge the informational content of the ECB's communication with respect to these different objectives. To the best of our knowledge this has not been done so far. We build on a standard model of the term structure to derive a structural estimation equation that allows to extract the effects of central bank communication on expectations about future interest rates. As we will show later, it is of major importance to not just analyze the ECB's communication by the wording but also to take into account what topics are addressed. This is clearly a very relevant issue that should be considered in future research in this area.

To quantify communication we employ the index from Berger et al. (2006a) (BHS henceforth). This ECB communication indicator portrays the views of all council members expressed in the pres-

[1] See e.g. Jansen and de Haan (2004)

ident's introductory statement at the monthly press conferences after a monetary policy meeting. It furthermore allows to quantify the ECB's statements on the different topics price stability, real economic developments and monetary developments separately and therefore allows to test for differences in financial market reactions to these topics.

Our estimations provide evidence that ECB communication can indeed influence short-term expectations and the shape of the yield curve at the short-end.[2] An interesting refinement of this result is the time structure: communication starts to become relevant for expectations about four months ahead. For maturities from four months up to one year the impact of a communication signal gradually increases. We interpret this in the following way: given a communication signal today, financial markets expect the ECB to change interest rates at the soonest four months later, but not earlier. An interest rate change is perceived to become more and more likely during the following four to twelve months. This finding shows that markets distill *the direction* of the upcoming step of the interest rate change from the statements and furthermore, that the ECB prepares them for a change in interest rate well in advance. The *timing* of interest rate changes, however, is still surrounded by uncertainty.

In a finer grained analysis we, furthermore, evaluate the relevance of the content and the topic of the statement. Especially information the ECB reveals on their interpretation of price developments is driving financial market expectations, whereas interpretations about monetary developments contain little "news" and communication about real economic developments even do not show any effect on asset prices. As it seems unlikely that financial markets have better measures of the monetary aggregate this supports the view that the development of monetary indicators is of minor relevance for the assessment of the ECB's strategy, confirming the analysis of Berger et al. (2006a). On the other hand financial market agents observe indicators that give them similar information on real developments the ECB has. The interpretation of the ECB about these appears to be no news to financial markets. Hence, there is less response to the ECB's assessment on the developments of the real economy. However, with respect to the ECB's view on price developments ECB communication contains new information for financial markets which they cannot extract from other sources such as macroeconomic data or their own models.

When analyzing the impact of communication on expectations during periods when real-time inflation is above the ECB's communicated target of close to but below two percent communication has a smaller impact on financial market expectations than during periods when inflation is within

[2] Long-run expectations as well as the long-end of the yield curve remain unaffected.

the target. This implies that communication is used to infer future monetary policy when hard economic data do not reveal clear information of where the path of interest rates is going.

The remainder of this chapter is structured as follows. Section 2.2 presents a literature overview. Section 2.3 gives the theoretical foundation for the estimation set-up. Section 2.4 introduces the data and the methodology we utilize. In Section 2.5 the results are presented and discussed while Section 2.6 draws the conclusions.

2.2 Literature Overview

Especially for a young central bank as the ECB, that is in a process of building up reputation, the central banks' communication catches a lot of interest. There is a broad consensus amongst researchers that central bank communication, by improving credibility and transparency, can enhance monetary policy outcomes and hence welfare.[3] Blinder et al. (2001) distinguish three channels through which clear communication can be welfare enhancing:

Firstly, communication can reduce transmission lags of monetary policy actions. The ECB controlled overnight interest rate has an effect on the real economy through inflation expectations. Arguably, a transparent central bank is more credible. This credibility induces wage and price setters to adjust quickly to policy changes. This in turn decreases transmission lags and therefore is beneficial for the effectiveness of monetary policy.[4]

Secondly, communication about the long-term inflation goal results in more credibility and thereby in greater trust in the commitment of the central bank to the target.[5] This allows the central bank to be more flexible in their response to shocks in the short-run (King, 1997). As an example, more transparency via clear communication reduces the costs of changes in the policy direction. Central banks usually try to avoid policy reversals, because these reversals may cause confusion about their future policy path. Forward-looking central banks might have to reverse policy decisions in response to other-than-anticipated economic developments. Via clear communication, the central bank ensures that the public understands such a reversal as an optimal response

[3] See, e.g. Blinder (1998), Woodford (2003 and 2005). For an overview see also Geraats (2002).

[4] See, e.g. Bernanke (2004).

[5] See Posen (2002) for a more extensive discussion on the gains in flexibility through transparency and communication.

to changing economic conditions and not as an attempt to push output above its potential.[6] Thus, clear communication ensures that reversals do not harm the credibility and reputation of a central bank (Lowe and Ellis, 1997).

Thirdly, communication may reduce volatility in markets and consequently improve the accuracy of monetary policy. Expectations about the future path of overnight interest rates affect the economy by being incorporated in longer-term interest rates, asset prices and exchange rates. As argued in the first point, central bank transparency and a sound communication can reduce uncertainty in expectations. Less uncertainty lowers the volatility in financial markets, thereby reduces financing costs and improves efficient allocation of resources. Furthermore, reduced volatility in expectations stabilizes the link between monetary policy and the economy: because the market's expectations about future changes in the overnight rate also influence market rates of much longer maturities today, they affect aggregate spending more effectively. Hence, communication induces a self-enforcing effect: communication reduces volatility in expectations which in turn offers the central bank a more precise estimate of the future impact of monetary policy decisions and hence increases the accuracy of monetary policy.[7]

On the other hand, some strands of the literature support the view that too much transparency may harm the effectiveness of monetary policy. Cukierman and Meltzer (1986) for instance show that being too precise in the announcement of targets would decrease the possibility of creating a policy surprise without loss of reputation.[8] In this respect precise announcements would lead to the time inconsistency problem in the line of Kydland and Prescott (1977). Hence, the central

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[6] A dependent central bank may be tempted to create monetary policy surprises in order to temporarily push output above its potential at the cost of inflation. This problem is referred to as "dynamic inconsistency", which is defined as a policy problem that can result if a policymaker has the ability, at a future time, to alter his strategy in a way that is inconsistent with both the desires and strategies of private individuals and with his own initially announced intentions. However, if a central bank is not credible, private agents anticipate the time inconsistent behavior of the central bank and rely on the inflation rate they expect in their wage contracts for the following period. This causes inflation to be higher in the next period but does not push output above its potential. The resulting inflation rate is referred to as "inflation bias". See Kydland and Prescott (1977) for the seminal discussion on the time inconsistency problem and Cukierman (1992) for a survey. However, this problem is less relevant for an independent central bank such as the ECB, as it has no incentive to push output or employment above the natural rate.

[7] See, e.g. Blinder et al. (2001), page 12.

[8] In this setting, the central bank has private information about its preference on the trade-off between monetary growth and economic stimulation. The public can only infer the current (time-varying) policy objectives from the noisy signal from the money supply. Thus, being not transparent and not revealing this private information to the public allows the central bank to engage in inflationary surprises when the marginal benefit of output is relatively high. Transparency in this case would allow the public to infer the central bank's goals and therefore future policy. Because monetary policy is assumed to affect the real economy only through surprises, transparency would not be beneficial for monetary policy. In the case of full transparency it would even become impotent.

bank does not reveal all its information. Stein (1989) and Garfinkel and Oh (1995) also argue that the announcement of imprecise and fuzzy statements (i.e. announcing a range) instead of a precise target would solve this inconsistency issue: the central bank can remain credible by not systematically failing to meet the target. They can also allow for deviations from their target, as long as the policy target is still within a previously announced range. A more relevant issue for the ECB is that revealing too much of their private information to the public may cause confusion. Financial markets receive more signals from the central bank and are therefore likely to overreact, as they are only able to digest a limited amount of information (Kahnemann, 2003). This in turn would increase volatility. A best response to this magnification of noise would be to reduce the precision in public announcements. Also Amato et al. (2002) point out that a better communication of the central bank may not always be welfare enhancing. Building on a model of Morris and Shin (2002), they show that, assuming that agents have access to independent sources of private information, an improvement of the precision of the public signal compared to the private signal may lower the average welfare function. Private agents would then rely on the public signal of the central bank despite they may have a comparative advantage in using their private signal. Thus expectations would be moved away from their fundamentals, which in turn harms the coordination of the central bank.[9]

Summing up, the picture emerging from the theoretical literature shows that the effectiveness of monetary policy is enhanced by harnessing the power of transparency via central bank communication. However, too much transparency might cause confusion and therefore too detailed central bank communication may be harmful for monetary policy effectiveness. Hence, theory gives no clear advice about the optimal design of communication to realize that communication indeed *"supports predictability and correct price formation in financial markets, contributes to efficient allocation of funds and reduces uncertainty about future interest rates"*, as postulated by Trichet (2005). This makes an empirical analysis necessary to evaluate the success of the ECB in achieving these goals.

Several attempts have been made to quantify the impact of communication on economic agents' expectations empirically. Most of the empirical literature analyzes the effect of commu-

[9]However, there has been a heated debate about this model in the context of central bank transparency. Svensson (2006) comments that their finding is actually *pro* transparency since their conditions are likely to be violated. Also Gosselin et al. (2006) question the assumptions of Morris and Shin (2002). They use an extended version of their model where the central bank must anyway publish some information by setting the interest rate. In this set up, full transparency is socially optimal in many cases. In some cases, however, the central bank can distill information to either influence public expectations or to reduce the unavoidable information content of the interest rate itself.

nication on the exchange rate. The evidence is rather mixed. While Jansen and de Haan (2005) find that efforts of the ECB to support the EUR-US$ exchange rate did not affect its level but rather increased its volatility, Fratzscher (2004) shows that communication can influence both the level as well as the volatility of the exchange rate. According to his results, it moves in the desired direction and reduces market volatility. Utilizing high frequency exchange rate data Jansen and de Haan (2007) report that ECB communication has only short-run effects on the EUR-US$ exchange rate.[10]

Heinemann and Ullrich (2007) compile a wording index based on certain signal words and use it to refine an estimation of a standard Taylor type rule. They conclude that the incorporation of their wording indicator can substantially meliorate the model predictions. Also besides exchange rates, money market rates reflect, as mentioned earlier, public expectations about *future* interest rate developments, too. In a similar vein, Andersson et al. (2004) find that speeches by the Sveriges Riksbank's central bankers are an important determinant for Swedish medium-term interest rates. For the Fed Demiralp and Jorda (2004) prove that public announcements affect short-term interest rates rather than the liquidity channel of open market operations. All these studies commonly support the supposition that central bank communication indeed affects expectations of financial markets. We extend this literature by not just analyzing *whether* communication has an effect on expectations on future interest rates, but also *over what horizon* these expectations are being affected and, hence, how well financial markets can predict the *future path* of interest rates by listening to the ECB's communication. Furthermore, we analyze which *kind of information* contained in the statements is particularly driving expectations and also *when*, i.e. during periods of higher or lower inflation than the target communication contains valuable news. We derive our estimation set-up from a theoretical model, which is presented below, that allows us to extract changes in expectations about future interest rates from money market rates.

2.3 The Expectations Theory of the Term Structure

Particularly long-term interest rates have an impact on the economy as they determine investment decisions and thereby influence aggregate demand. As central banks only control a limited number of short-term interest rates on the money market, including what is for the ECB called the main refinancing bid rate with a maturity of nowadays one week (repo), the pass-through of short-run

[10] In Chapter 3 we will survey the literature in more detail.

to medium- and long-run interest rates is extremely important for monetary policy.[11] Roley and Sellon (1995), amongst others, show how medium- and long-term interest rates are affected by current interest rates–a model commonly known as expectations theory of the term structure. The main component of this link are the expectations markets have about future short-term interest rates. We make use of this model of the term structure, which motivates the relationship between the short-term policy controlled interest rate and medium- and long-term interest rates and add an effect of the central bank's communication on financial market expectations.

$$r_t^M = E_t \left[\sum_{s=0}^{M} repo_{t+s} \right] /M + \rho. \tag{2.1}$$

The underlying concept of equation (2.1) is the so-called expectations hypothesis of the term structure.[12] The basic idea is that, with the exception of a term premium, there should be no difference in the returns from holding a long-term bond or rolling over a sequence of short-term bonds. As a result, the long-term interest rate should be an average of future expected short-term interest rates plus a term premium (e.g. Dotsey and Otrok, 1995). The reasoning behind this is that two equivalent investment options should have the same expected return, otherwise investors would arbitrage away any differences.[13] From equation (2.1) we see that the longer the maturity of an interest rate r, the longer the time horizon of expectations about future repo rates. Assuming that k_i equals the number of days between day t and meeting i and $i = 1, ..., j$ is the number of meetings from t to $t + M$, the interest rate of a money market or government bond at t (equation 2.2) and $t + 1$ (equation 2.3) respectively is

[11] Sellon (2004) gives an excellent overview of the expectation hypothesis and the role of expectations for the monetary policy transmission.

[12] Following for example Gurkaynak et al. (2002) a change in expectations about future interest rates can be derived from the rate r_t^M on a market instrument. The rate of return at time t with maturity M is determined by the expected return from the repo rate *repo* plus a constant reflecting a term premium ρ (which is assumed to remain constant from a meeting day to the day after). Thus an investment with maturity M in t with a fixed rate of return in $t + M$ equals the expected return on an investment in t for M periods in the repo rate.

[13] King and Kurmann (2002) note that, although the rather strong implications of this theory have been rejected in various studies, there nonetheless remain important elements of truth. Therefore, many central bankers and other practitioners of monetary policy continue to apply it as an, admittedly, imperfect but still useful benchmark. Fuhrer (1996) shows that, when accounting for changes in the monetary policy regime, this model is fitted well by the U.S. data. As we include communication, it is reasonable to assume that a shift in the monetary policy regime would be captured by the change in the communication variable. Hence, we use this common theory as an underlying foundation for our empirical set-up.

$$r_t^M = \frac{1}{M} repo_t + \frac{k_1}{M} E_t[repo_{t+1}] + \frac{k_2 - k_1}{M} E_t[repo_{t+k_1+1}] + \dots + \frac{k_j - k_{j-1}}{M} E_t[repo_{t+k_{j-1}+1}] + \frac{M - k_j}{M} E_t[repo_{t+k_j+1}] + \rho \tag{2.2}$$

$$r_{t+1}^M = \frac{k_1}{M} repo_{t+1} + \frac{k_2 - k_1}{M} E_{t+1}[repo_{t+k_1+1}] + \dots + \frac{M - k_j + 1}{M} E_{t+1}[repo_{t+k_j+1}] + \rho. \tag{2.3}$$

Taking the first difference allows to cancel out the risk premium and formulate the first difference of r as a function of a surprise (given by the expectation of the expected value of the ECB's rate prior to the meeting and the actual announced value) and the change in expectations on future $repo$ rates from t to $t+1$.

$$\begin{aligned} r_{t+1}^M - r_t^M = {} & \frac{k_1}{M} \left(repo_{t+1} - E_t[repo_{t+1}] \right) \\ & + \frac{k_2 - k_1}{M} \left(E_{t+1}[repo_{t+k_1+1}] - E_t[repo_{t+k_1+1}] \right) + \dots \\ & + \frac{1}{M} \left(E_{t+1}[repo_{t+k_j+1}] - E_t[repo_t] \right) \\ & + \frac{M - k_j}{M} \left(E_{t+1}[repo_{t+k_j+1}] - E_t[repo_{t+k_j+1}] \right) \end{aligned} \tag{2.4}$$

Simplifying equation (2.4) yields the following equation

$$\Rightarrow \Delta r_{t+1}^M = c_1 \left(repo_{t+1} - E_t \left[repo_{t+1} \right] \right) + \sum_j c_{j+1} \Delta E_{t+1}[repo_{t+k_j+1}] + \varepsilon. \tag{2.5}$$

For our estimations, we use an event-study approach, i.e. the index t does not have a specified frequency. The subscript t denotes the day of a meeting. The changes in the rates from these days

to the days after the meeting $t+1$ are included in our data set.[14] Overall our data set contains 68 meetings, the first in January 1999 and the last in December 2004. Following the derivations above the day to day change of interest rates as presented in equation (2.5) is a function of two distinct components. The first is the difference between the resulting repo rate set by the ECB council and the repo rate which was anticipated by market participants and hence captures the unexpected component (surprise) in the ECB's decision. The second source of news which may affect the change in expectations is mainly driven by the informational content of the introductory statements. The statements can be informative for financial markets as they can use the central bank's assessment of the economic situation and the information on their pursued strategy to adjust their expectations.[15] This information should be adequately proxied by the change of the communication indicator. A significant impact of the communication indicator would mean that agents use information they extract from the press releases about the interpretation of economic developments and the monetary policy stance in addition to the new information from the new level of the ECB's rate to form their expectations about future interest rates.

Hence, following equation will be tested empirically:

$$\Delta r_{t+1}^{M} = c_1(repo_{t+1} - E_t[repo_{t+1}]) + c_2 \Delta comm_t + \varepsilon. \tag{2.6}$$

We will estimate the change of the Euribor rates as a function of the surprise in the interest rate decision measured by the difference of the new refinancing rate and the expected refinancing rate derived from the Reuters survey of professional forecasters and the information content of the introductory statements measured by the change in our communication indicator. To analyze the dynamic aspects of the relationship we employ Euribor rates at different maturities. Information revealed by ECB statements is likely to have a different impact on different maturities.[16]

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[14] The timing is the following: At 11.00 CET we measure the spot rate of r_t, then the decision of the Governing Council meeting at t is being announced at 13.45 CET. In the following press conference, which is always at 14.30 CET, the Press Conference is started with the Introductory statement read out by the ECB's President. On the following day at 11.00 CET we measure the spot rate of r_{t+1}, when the relevant information released on the meeting day is incorporated into the Euribor rates. Throughout the thesis all dates are reported as Central European Time (CET).

[15] That private agents "learn" about the unobservable objectives of monetary policy makers is an assumption that the literature on learning and monetary policy makes use of. For example, Orphanides and Williams (2003 and 2005) show that in this modelling set-up, the revealing of information by the central bank on their policy objectives generally leads to better economic outcomes. See also Bernanke (2004).

[16] We assume that on the day of the ECB meeting no other new information is systematically released, i.e. additional information is distributed randomly and captured in the error term. Hence, to a large extent movements of the different Euribor rates can be attributed to information reflecting the monetary policy stance as presented at the ECB press conference.

Another topic of interest is the effect on the slope of the yield curve. All these market interest rates can be expressed as a function of their maturities, a relationship that is known as the so-called yield curve.[17] A flat yield curve indicates that the agents at financial markets expect the interest rates to remain mostly equal over the horizon that the yield curve is constructed over. A downward sloping yield curve implies that financial markets expect a lower interest rate in the future. Respectively, an upward sloping yield curve reflects that a future higher level of interest rates are expected. Hence, if a factor influences only the interest rates at lower maturities, but not at higher maturities, only the so-called "short-end" of the yield curve is affected, which means that financial markets expect an effect of the factor of interest on interest rates in the short-term, but no change in the course of nominal interest rates in the long-term (Roley and Sellon, 1995). One line of the macro finance literature not just interprets changes in the slope of the yield curve as indicator for future changes in the economic situation but also of a change in monetary policy targets (Fuhrer, 1996). This would mean that the yield curve flattens if the short-term interest rates are expected to increase only temporarily and long-term rates remain at their current level and a steepening of the curve in case of a decrease of short-term rates respectively. A deviation from the current monetary policy target, however, moves long-term rates as well.[18] A sound communication of the central bank with financial markets should be able to prepare financial markets for an upcoming change in the repo rate, and hence should affect the short-end of the yield curve. However, if the long-end of the yield curve was affected, expectations about the long-term target of inflation would have changed, which would imply that the financial market interprets a statement of the central bank as a persistent change in the stance of policy. Depending on the direction of the change, this could be either a sign of successful communication that leads to anchoring inflation expectations at a lower inflation level or it could be a sign of inadequate communication that makes markets expect a higher inflation level in the future. A frequent impact of these statements on long-term interest rates would thus cause volatility in long-term interest rates, which–as argued in the theoretical part–would be an obstacle to an efficient allocation of resources.

The slope as proxied by the difference between two maturities decreases when short-term rates become more equal to long-term rates and hence expectations about the perception of the course of monetary policy can be estimated from the slope of the yield curve.

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[17] See Campbell (1995) and Cook and Hahn (1990) for an overview on the relationship between interest rate expectations and the shape of the yield curve.

[18] See, e.g. Evans and Marshall (2001). Also Bomfim (2003) formulates a two-factor model of the term structure of interest rates and shows that the shape of the U.S. Treasury yield curve can be explained by one factor corresponding to the current setting of the federal funds rate and the second by medium-term policy expectations.

To analyze how communication affects the shape of the yield curve we proxy the slope by the spreads between different maturities. Given that interest rates with higher maturities are affected by the whole trajectory of expected short-term rates, the slope of the yield curve contains important information. Hence, from equation (2.4) we subtract the change of Δr_{t+1}^{m} with a lower maturity $m<M$ from the left hand side of the equation.

$$\Delta r_{t+1}^{M} - \Delta r_{t+1}^{m} = b_1(repo_{t+1} - E_t[repo_{t+1}]) + \sum_{j=m}^{M} b_{j+1}\Delta E_{t+1}[repo_{t+k_j+1}] + \varepsilon. \quad (2.7)$$

Equation (2.7) formulates the change of the spread between interest rates of different maturities as a function of the expected change in the repo in the time between m and M in the future.

The considerations above eventuate in the following estimation equation:

$$\Delta r_{t+1}^{M} - \Delta r_{t+1}^{m} = b_0 + b_1(repo_{t+1} - E_t[repo_{t+1}]) + b_2\Delta comm_t + \varepsilon. \quad (2.8)$$

The left hand side of equation (2.8) represents the change in the slope of the yield curve between maturities m and M. Analogously to equation (2.6), this slope of the yield curve is a function of the unexpected change of the repo and the expected future stance of monetary policy, which can be extracted from information inherent in the communication indicator.

2.4 Data

As the underlying idea of our analysis is to check whether and to what extent ECB communication affects expectations of financial market agents, we need two types of indicators. On the one hand, we need to utilize interest rates data to extract financial market expectations and reactions as derived in Section 2.3. On the other hand it is necessary to find an indicator that captures the communication of the ECB. The latter is obviously a problem as it is hard to quantify "communication".

2.4.1 Financial Market Data

We look at financial market agents for two reasons: first, financial markets watch the ECB closely and are not expected to be biased from media coverage, which was found by De Haan and Amtenbrink (2002). Second, it is possible to extract expectations about future monetary policy from bond markets, as shown in Section 2.3. For the Euro area, the Euribor investment products are interest rates, which are traded on the money market with maturities of one week to twelve months. These rates are useful for our analysis as they are complementary to the interest rates we derived theoretically in the preceding section. For our analysis, we use the change in the Euribor data as our dependent variable with all available monthly maturities (one to twelve months).[19] Data for the Euribor can be downloaded from `www.euribor.org`.

One explanatory component is the market surprise due to the unexpected change in the refinancing rate set by the ECB. This monetary policy surprise is computed by deducting the expectation of the announcement from the actual announcement value of the ECB's interest rate. The expectation is depicted by the mean of the Reuters survey of professional forecasters' expectations of the monetary policy decision. This measure is selfsame to the one used in Ehrmann and Fratzscher (2005a), who show that these survey expectations are generally unbiased and efficient. The second explanatory variable for the change in the Euribor rate is the effect of the introductory statement as measured by the change in the BHS communication indicator.

2.4.2 The Berger-de Haan-Sturm ECB Communication Indicator

Most of the empirical studies focus on the impact of communication events such as central bankers speeches or central bank statements. Mostly, binary proxies are used (i.e. if there was a statement or not). This, however, only allows to analyze the effect of a statement, no matter what the content is. In reality financial markets closely watch central bankers lips and analyze their speeches thoroughly. Therefore, we need a measure that allows us to quantify *contents* of these statements.

[19] Unfortunately, the Euribor is only available for maturities up to twelve months. To obtain financial market data for higher maturities we would have to use government bond yield data. As the Eurostat data for government bond yields for the Euro area are aggregated from country specific bond yields, the aggregate might be driven by country specific factors rather than the monetary policy stance. Bernoth et al. (2003) empirically analyze the government bond yield differentials between EU countries. They find that the differentials can be explained to a large extent by a positive default and liquidity risk premium. They increase with the debt, deficit and debt service level and depend positively on the issuer's relative bond market size. Taking this into account, we opt to focus on Euribor data only.

Some recent studies like Heinemann and Ullrich (2007) identify "code words" from ECB statements or publications to construct indicators for "hawkishness" in ECB statements. The advantage of such approaches is that they are relatively mechanical in quantifying ECB communication and are therefore in principle reproducible. Financial market agents, especially the so called "ECB Watchers", however, exactly analyze the statements and pay particular attention to the content of these statements. This is especially important as Berger et al. (2006a) for example find that these sub-indicators weight differently in the overall assessment of the ECB. Hence, there is no distinction of whether a "code word" such as "upside risk" is related to developments in the real economy, in prices or in money growth. This, however, might be important, as the interpretation of the ECB on developments in one sector may be more or less expected by financial markets, whereas interpretations on other sectors might come as a surprise and thus –if considered to be important– significantly affect expectations about future interest rates. The mechanical quantification by only counting certain expressions therefore disregards too much information relevant for our purpose. Incorporating the entire content and allow for "reading between the lines" – as is done by Berger et al. (2006a) – seems to be more appropriate in our case.[20]

Thus, the advantage of the BHS indicator is that it uses both subjective measurements of content of introductory statements of the ECB's monthly press conference and that also each of the statements are quantified separately with regards to (1) price developments p, (2) the real economy ec, (3) the monetary sector m, and finally (4) the overall conclusively assessment of the current situation ag are quantified.[21]

One issue in this respect is a sensible weighting of the index. We use a principal components analysis (pca) twice: firstly, we have to cancel out subjectivity across the different individuals that rated the statements. Therefore, we use the pca to extract the common information contained in

[20] The indicator is constructed on the basis of the information communicated in the ECB's introductory statement at the press conference following an interest rate meeting. The introductory statements play a crucial role as the ECB itself highlights them as the most important communication device besides the monthly bulletin. This approach accounts of the fact that the ECB follows the collegial communication approach, as discussed by Ehrmann and Fratzscher (2007a), as the content of these statements reflects the views of *all* members of the council. These statements should therefore also contain important information for interest rate expectations. Indeed, Ehrmann and Fratzscher (2005c) find that the predictability of interest rates for financial markets significantly improves when analyzing communication that does not reflect dispersion across council members' opinions but rather their consensus.

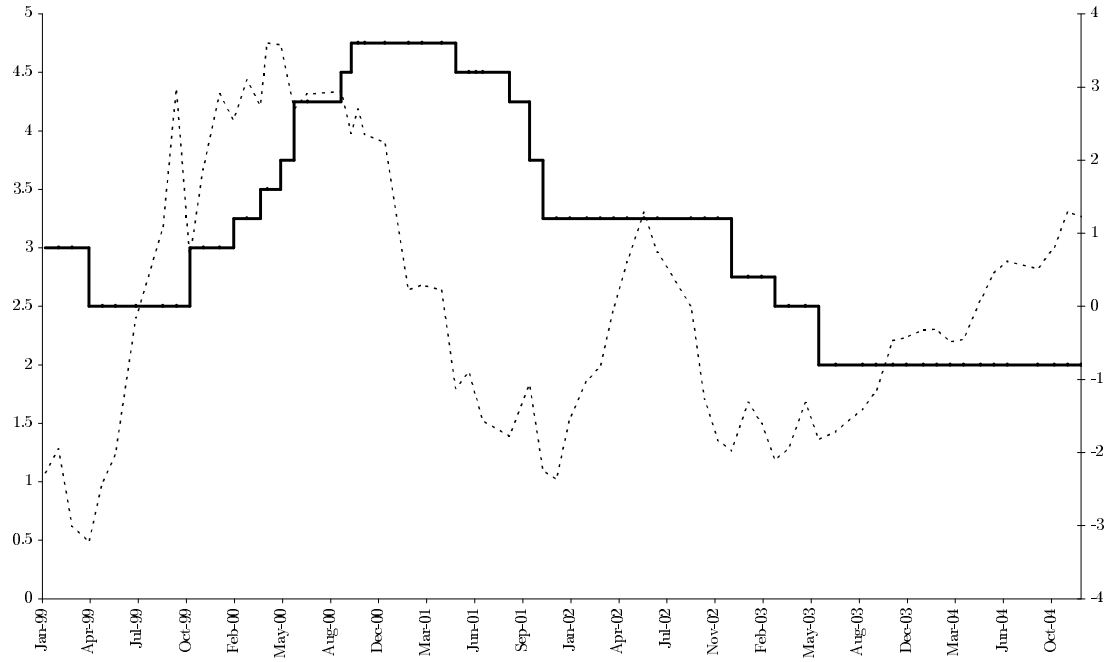
[21] Three independent economists read the ECB introductory statements and rated each month's statement on prices and price developments, the real economy, the monetary sector and the overall conclusively assessment of the current situation using a scale from -3 to +3. Despite their economic background, these junior researchers were on purpose non-experts in the field of monetary economics, i.e. they were not biased by actual and past policy discussions in this field.

the different subjective ratings on price developments to obtain a series of ag. We run an analogous procedure to cancel out subjectivity of the different ratings to obtain series for ec, m and p. We call the series obtained from the aggregation of the series that quantify ag "aggregate communication indicator" or "BHS indicator" henceforth.[22] This approach allows to cancel out subjectivity to a large extent.[23] Furthermore, by using not only the information from the overall statement but also from those parts of the statements that address prices, real and monetary developments, we also analyze how expectations react to the contents of the statements distinguished by topic as measured by p, ec and m. This allows us to disentangle the "news" contained in the introductory statements in these three sectors from each other. Financial markets have already incorporated the (real-time) information on the latest available business cycle indicators, inflation rates and monetary aggregate indicators. What is "news" to them is the interpretation of these developments by the ECB. Hence, some of the paragraphs addressing these sectors separately might contain more important "news" than others. We have computed the correlation coefficients between the real-time developments given by "hard" data (i.e. the latest data available in real time) and the single indicators. The correlation between the real-time economic sentiment indicator (ESIN) and the sub-indicator ec is 0.64; for the real-time M3 growth and the sub-indicator m the correlation is still 0.20 and for the real-time HICP and p, the correlation is 0.00. Hence, the statement and interpretation of the ECB on real developments follows quite closely the currently available data and hence the "news" content on statement days should be quite small. On the other hand, there is no correlation between real time HICP rates and the ECB's statement on current and future price developments. This is also a finding in Berger et al. (2006a), who conclude, that the contents of

[22] To capture the impact of the weighting scheme on the results we basically compare two more approaches. We use the three indicators of ag and cancel out subjectivity by computing simple averages of the three series. The reason for using only the rankings of ag is that the overall assessment mostly summarizes a large part of the rest of the statement, i.e. p, ec, and m, which would include information on some of the sub-indicators unproportionately: Berger et al. (2006a) find that the assessment of the monetary sector becomes less important in the second half of our observation period. Including the assessment on the monetary sector with an equal weight as the other two sectors ec and p would give the impact on the communicated importance of the monetary pillar too much weight relatively to the other two sub-sectors. Second, we weight each of the sub-indices by the amount of words spent on each topic. This measure does not include the ag indicator, as for most of the cases, the overall impression cannot directly be attached to a specific paragraph in the statements. A relevant development that affects central banking should be measured by the index but also honored by an in-depth discussion, consequently leading to long text passage and a large amount of words. The correlation coefficients between the three alternative indices spawned by the different weighting schemes lies between 0.95 to 0.99.

[23] Comparing the output it becomes evident that all three weighting schemes lead qualitatively to the same results. Hence we opt to present only the results of one weighting scheme. In terms of performance, as measured by the goodness of fit, the principal component weighted indicator dominates the other two.

Figure 2.1: ECB Communication Indicator and Main Refinancing Bid Rate



Left hand scale: ECB Main Refinancing Bid Rate (solid line); right hand scale: ECB Communication Indicator, weighted by principal components (dashed line); source: ECB, Berger et al. (2006a) and authors calculations.

the statements with respect to price developments are more forward-looking and therefore contain not much information on recent data interpretations but rather on the ECB's price development expectations. Hence, the ECB's statements seem to have more information content for future interest rates than the latest HICP data.

Our measurement of the overall communication is plotted together with the main refinancing bid rate in Figure 2.1. The indicator seems to lead the interest cycle, which confirms that the ECB tries to prepare markets for an increase in interest rates. However, the indicator still shows a non-deniable volatility which might be due to the indicator's construction but might also lead to the conclusion that communication is still noisy and ambiguous to some extent. Therefore, the analysis of financial markets' understanding of ECB communication is an important issue for monetary policy.

2.5 Results

As derived in the last section we want to analyze the impact of communication by explaining the day-to-day change of the Euribor by the unexpected change of the ECB refinancing rate (measured by the difference between the Reuters survey and the actual refinancing rate) and the change of the communication indicator. We estimate equation (2.6) for all available maturities of the Euribor. The results are reported in Table 2.1. Overall, the significance of the BHS indicator in explaining day-to-day changes of medium- to long-term interest rates shows that ECB communication indeed plays a prominent role in forming expectations of market agents. Besides that, the monetary policy surprise is sizeable and highly significant at every maturity. This suggests, that both the news from deeds and from words matter for financial market participants' expectations.

Having a closer look at the estimation results across the different maturities reveals an compelling picture: the BHS indicator is significant for maturities from six up to twelve months. Interestingly, Euribor rates with lower maturities are not affected by a change in the communication signal.[24] The effect of a change in our communication indicator on the Euribor rates at different maturities is plotted in Figure 2.2.

The figure shows that the size of the communication effect increases for maturities up to twelve months. However, the level of these impact coefficients are not statistically different from each other.[25] The overall monetary policy stance as communicated via the introductory statements of the ECB president mainly appears to affect medium- to long-term expectations on financial markets. Given that we measure the overall stance of monetary policy with the BHS indicator, we find that financial markets expect to be prepared for a change in the repo rate due to a change in the monetary policy stance at least six month before the decision to change the repo rate is actually conducted. Another interesting result is that only the change in the wording indicator is significant. Implementing the absolute index in the estimation equation leads to barely significant results. Hence, financial markets especially react to changes of the statements rather than to the overall risks expressed in the statements.[26]

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[24] Note, we opt to control for a sizeable peak in the one month maturity series. Residuals statistics as well as the news headlines suggest a anomaly on 8 Oct. 1999. Comparing estimations —with respectively without the control— a gaugeable change appears only for the overall indicator at the one month maturity where the coefficient becomes insignificant.

[25] Estimates on the difference are reported in the following paragraph.

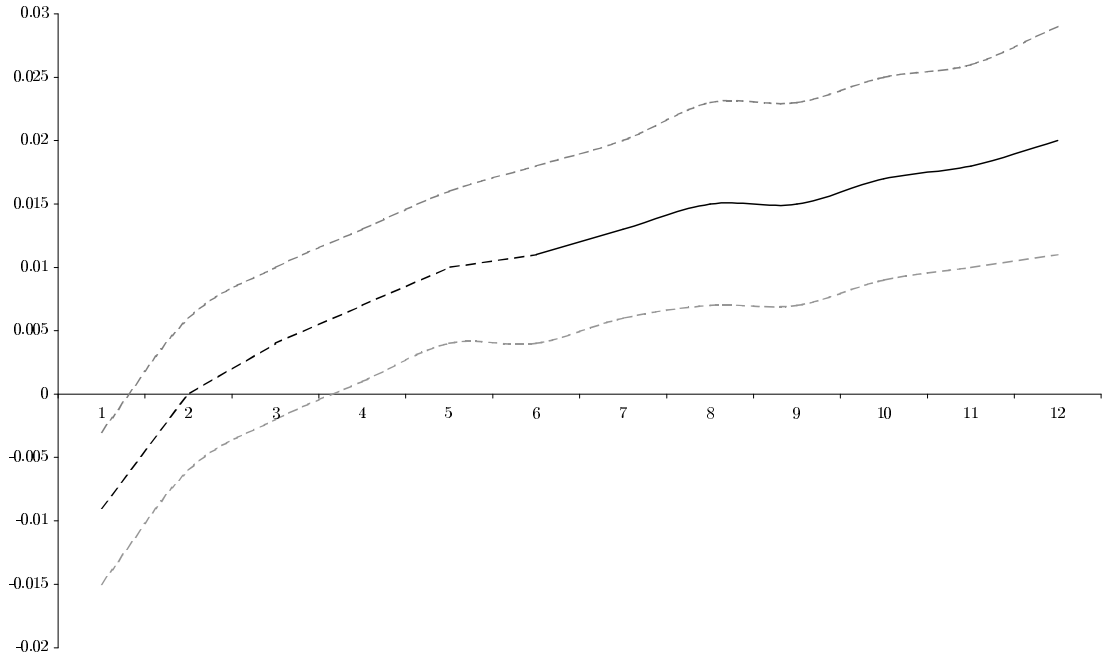
[26] This is in line with the findings of Heinemann and Ullrich (2007), who find that only the change of their wording indicator significantly improves a standard Taylor rule type.

Table 2.1: Results Impact of Communication

Maturity	1M	2M	3M	4M	5M	6M	7M	8M	9M	10M	11M	12M
Cons	0.001	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.006	0.006	0.006	0.007
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
$\Delta comm$	-0.009	0.000	0.004	0.007	0.010	0.011*	0.013*	0.015*	0.015*	0.017**	0.018**	0.020**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)
SURP	0.541***	0.47***	0.437***	0.441***	0.436***	0.438***	0.45***	0.448***	0.452***	0.459***	0.464***	0.462***
	(0.052)	(0.050)	(0.049)	(0.048)	(0.048)	(0.053)	(0.057)	(0.061)	(0.063)	(0.065)	(0.067)	(0.070)
R-Squ.	0.682	0.611	0.549	0.562	0.549	0.505	0.485	0.447	0.432	0.426	0.420	0.405
Obs.	67	67	67	67	67	67	67	67	67	67	67	67

Note, dependent variable: Δr^M_{t+1}; Robust standard errors in parenthesis; ***/**/* denote the 1/5/10%-significance level.

Figure 2.2: Coefficients Values at Different Maturities



X-axis: maturity, Y-axis: coefficient value, solid line: at 10% significant coefficients, dashed lines: coefficient bands one standard deviation.

To ferret out if developments in specific areas of the economy– price, real or monetary issues – discussed in an introductory statement are particularly relevant (and over which horizon) for market participants we regress the sub-indicators using the same setup. Results are presented in Table 2.2.

We find that the price indicator is highly significant from three months to one year. In contrast, the monetary indicator is only relevant between two to seven months. The real indicator is insignificant at all maturities. This result is intuitively appealing. The current developments in the real economy can be inferred from survey data, that are available on a high frequency and have good forecast properties. Arguably, the picture the ECB has is similar to the picture the financial markets have, as interpretations of these data are relatively similar. The "news" that statements contain about the central bank's interpretation of the data are therefore negligible.[27] According to our

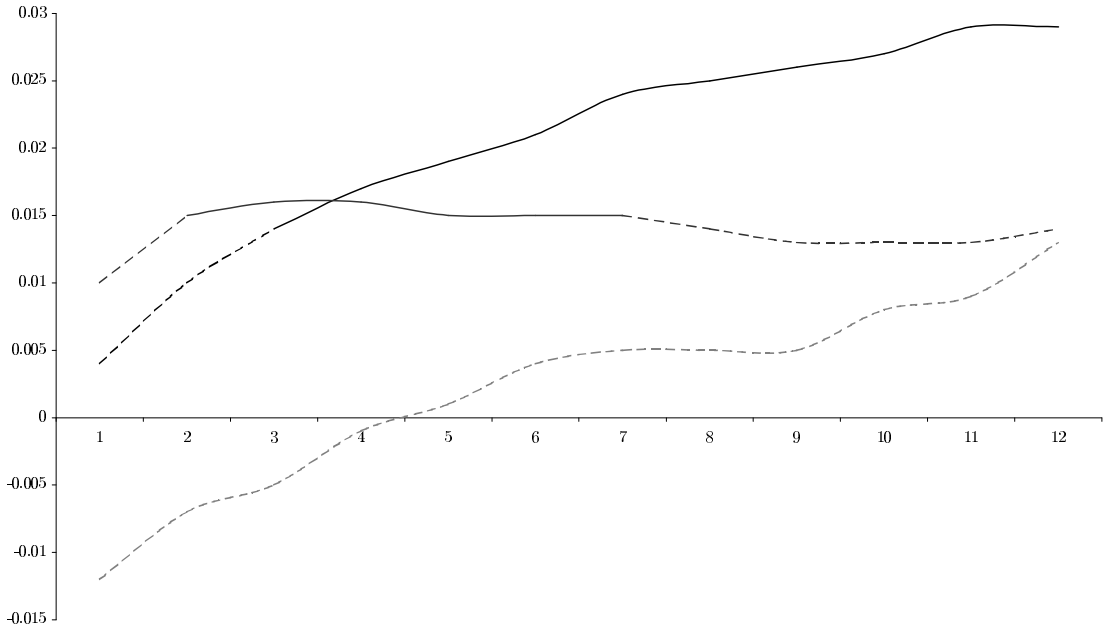
[27] This is also in line with earlier findings, that suggest that economic outlook communication generally moves financial markets only very little (Ehrmann and Fratzscher, 2005d).

Table 2.2: Results Sub-Indicators Impact of Communication

	Maturity	1M	2M	3M	4M	5M	6M	7M	8M	9M	10M	11M	12M
Prices	Cons	0.001	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.006	0.006	0.006	0.007
		(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)
	$\Delta comm$	0.004	0.01	0.014 *	0.017 **	0.019 ***	0.021 ***	0.024 ***	0.025 ***	0.026 ***	0.027 ***	0.029 ***	0.029 ***
		(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)	(0.010)	(0.011)	(0.011)	(0.011)	(0.012)
	SURP	0.55 ***	0.468 ***	0.429 ***	0.429 ***	0.421 ***	0.42 ***	0.43 ***	0.426 ***	0.429 ***	0.433 ***	0.437 ***	0.433 ***
		(0.052)	(0.049)	(0.047)	(0.046)	(0.047)	(0.052)	(0.055)	(0.059)	(0.062)	(0.064)	(0.066)	(0.068)
	R-Squ.	0.672	0.62	0.567	0.582	0.569	0.525	0.506	0.467	0.451	0.441	0.434	0.414
Real	Cons	0.001	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.006	0.006	0.006	0.007
		(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
	$\Delta comm$	-0.012	-0.007	-0.005	-0.001	0.001	0.004	0.005	0.005	0.005	0.008	0.009	0.013
		(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.012)	(0.012)	(0.013)	(0.014)	(0.014)	(0.015)	(0.015)
	SURP	0.548 ***	0.469 ***	0.431 ***	0.433 ***	0.426 ***	0.427 ***	0.437 ***	0.434 ***	0.437 ***	0.442 ***	0.446 ***	0.443 ***
		(0.052)	(0.050)	(0.048)	(0.048)	(0.049)	(0.054)	(0.058)	(0.062)	(0.065)	(0.067)	(0.069)	(0.071)
	R-Squ.	0.677	0.613	0.548	0.552	0.53	0.483	0.458	0.415	0.399	0.388	0.38	0.363
Money	Cons	0.001	0.000	0.000	0.002	0.003	0.004	0.005	0.005	0.005	0.006	0.006	0.007
		(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
	$\Delta comm$	0.010	0.015 **	0.016 **	0.016 **	0.015 **	0.015 *	0.015 *	0.014	0.013	0.013	0.013	0.014
		(0.008)	(0.008)	(0.007)	(0.007)	(0.008)	(0.008)	(0.009)	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)
	SURP	0.550 ***	0.470 ***	0.432 ***	0.433 ***	0.425 ***	0.425 ***	0.435 ***	0.432 ***	0.435 ***	0.44 ***	0.444 ***	0.44 ***
		(0.051)	(0.048)	(0.047)	(0.046)	(0.048)	(0.052)	(0.056)	(0.061)	(0.064)	(0.066)	(0.068)	(0.071)
	R-Squ.	0.678	0.634	0.578	0.583	0.558	0.508	0.481	0.434	0.413	0.401	0.391	0.370
	Obs.	67	67	67	67	67	67	67	67	67	67	67	67

Note, dependent variable: Δr^M_{t+1}; Robust standard errors in parenthesis; ***/**/* denote the 1/5/10%-significance level.

Figure 2.3: Impact Sub-Indicators at Different Maturities



X-axis: maturity, Y-axis: coefficient value, dashed lines: coefficients insignificant at 10% significance level, dark line: Price indicator, dark grey line: Money indicator, light grey line: Real economy indicator.

results, especially the ECB's interpretation on current and expected price developments surprises financial markets. The interpretation on price developments is also perceived to be of high importance: comparing the effect of the price communication indicator with the effect of the aggregate indicator, the coefficients have roughly the double size for the price indicator. Also comments on monetary developments reveal some "news" for financial markets for the medium-term of two to seven months ahead expectations.[28] Figure 2.3 additionally highlights the importance of the price component in comparison to the other sub-components of ECB statements.

[28]Berger et al. (2006a) find that the communication strategy changed during the observation period: especially the (minor) role the ECB attached to monetary developments changed. Hence, the significance of this indicator could reflect the fact that financial markets noticed the role of monetary developments only over the course of the years and thus reacted to the interpretations in the first place, but, after noticing that the monetary sector appears to play a minor role in the ECB's strategy, did not react to the monetary developments-statements afterwards.

Table 2.3: Difference Matrix Maturities (1-12 Months)

	1M	2M	3M	4M	5M	6M	7M	8M	9M	10M	11M	12M
1		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.568		0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.001
3	0.465	0.255		0.015	0.008	0.012	0.009	0.011	0.014	0.008	0.013	0.014
4	0.425	0.253	0.127		0.016	0.031	0.020	0.024	0.027	0.014	0.023	0.025
5	0.414	0.255	0.151	0.146		0.133	0.041	0.043	0.048	0.023	0.037	0.039
6	0.384	0.235	0.145	0.121	0.081		0.023	0.034	0.045	0.016	0.034	0.035
7	0.358	0.228	0.156	0.134	0.124	0.140		0.104	0.110	0.026	0.064	0.062
8	0.342	0.219	0.151	0.131	0.117	0.117	0.103		0.237	0.026	0.091	0.081
9	0.334	0.217	0.154	0.137	0.127	0.126	0.115	0.099		0.011	0.086	0.080
10	0.332	0.220	0.158	0.142	0.130	0.133	0.117	0.103	0.090		0.808	0.351
11	0.326	0.216	0.154	0.139	0.128	0.126	0.107	0.093	0.072	0.060		0.204
12	0.322	0.213	0.150	0.134	0.122	0.122	0.106	0.091	0.071	0.062	0.055	

Note, upper right triangular part depicts p-values, lower left triangular part shows R-Squares.

These results are consistent with our argument that the interpretation of the ECB on economic developments is expectedly close to what financial markets read from current business cycle indicators. Their interpretation of price developments, however, is much driven by their outlook on future price developments, that mostly are private information to the central bank. Somewhere between these two extremes lies the (lower) surprise generated by the interpretation of monetary developments.

So far our results show that communication has indeed an effect on bonds with a specific maturity. These findings only allow to draw conclusions for single points on the yield curve separately. However, from a policy perspective, it is equally important to check the effect of communication on the slope of the yield curve, which is commonly proxied by the spreads between the bonds at different maturities. Hence, we also estimate the response of the slope of the yield curve by estimating equation (2.7) using all possible permutations between maturities. This allows us to draw a picture of the effect on the slope of the yield curve.

Our estimates reported in Table 2.3 show the significance (expressed in p-values) of an effect of communication (aggregate indicator) on the *slope* of the yield curve using all permutations of proxies for the slope between one month and twelve months maturity. There is a significant different impact from communication on one to eight months compared with higher maturities. Hence, the relation between short- and medium-term interest rates alters significantly. None of

the spreads between higher-than-eight months maturities is shifted significantly by the change in the communication indicator derived from the ECB press statements. The lower triangular matrix in Table 2.3 shows the R^2 of the regressions of equation (2.7). The first and second columns exhibit larger values than the remaining columns, which shows that the communication indicator can explain up to 50 percent of the yield curve slope variation between one and two months maturity, and 16 percent of the variation in the slope of the yield curve on meeting days between one months and twelve months maturity. Recalling that these spreads proxy for the slope of the yield curve, this result substantiates our findings when testing the absolute responses in Table 2.1, where we did not find significantly *different* coefficients. This indicates that markets cannot distill the future path of interest rates from communication. They anticipate the direction and the timing of the upcoming step which is to be conducted in a horizon of about six to twelve months ahead.

To check the consistency of our results we investigate two further issues: first, we analyze whether the impact of ECB communication has changed over time. Second, we explore whether the effect of ECB communication is different during periods when the inflation rate is above the ECB's communicated objective of close to but below two percent.

To tackle the first point we perform robust regressions: it is reasonable to assume that in the early meetings market participants had to learn how to interpret the statements of the ECB. Hence, inappropriate reactions may have occurred. Such effects may also impact our estimation results in tilting the regression line. Hence, to verify our estimation results we employ least trimmed squares (LTS) estimation with robust standard errors as introduced by Rousseeuw and Leroy (1987). This estimation technique has been proved to be extremely robust to outliers and reasonable efficient. Table 2.4 exhibits the estimation results. Overall, it solidifies our inferences. It remains a significant effect of communication which is largely driven by the information content of prices. Moreover, it clearly reveals, especially for short to medium maturities, the presence of outliers. It seems that those maturities are particularly volatile.

To scrutinize the second point we need to re-construct the latest information that was available to the ECB and financial markets about the real time inflation rate at the meeting day. Hence, we use the flash estimate of the HICP if this was the latest information available or the release of the final version of the HICP, respectively.[29] We then generate a dummy variable that has the value one when real time inflation was above or equal to two percent and zero when it was below. Then we interact this dummy with the communication indicator variable. Doing this allows us to

[29]Since Nov 2001 Eurostat publishes a preliminary estimate on the Euro area inflation rate of the current month on the end of that month before, approximately two weeks after the actual number is being released.

Table 2.4: Least Trimmed Squares (LTS) Results Impact of Communication

		1M	2M	3M	4M	5M	6M	7M	8M	9M	10M	11M	12M
All	Cons	0.000	-0.001 *	0.001	0.003	0.001	0.001	0.003	0.005	0	0.001	0	-0.001
		(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
	$\Delta comm$	-0.002	0.001	0.001	0.001	0.003	0.004	0.007	0.006	0.013 *	0.015 **	0.016 *	0.021 ***
		(0.002)	(0.001)	(0.001)	(0.003)	(0.005)	(0.006)	(0.006)	(0.007)	(0.007)	(0.008)	(0.008)	(0.009)
	SURP	0.215 ***	0.241 ***	0.225 ***	0.184 ***	0.163 ***	0.179 ***	0.149 **	0.148 **	0.302 ***	0.305 ***	0.306 ***	0.368 ***
		(0.037)	(0.013)	(0.013)	(0.038)	(0.048)	(0.056)	(0.068)	(0.072)	(0.096)	(0.096)	(0.093)	(0.078)
	R-Squ.	0.45	0.846	0.782	0.292	0.158	0.116	0.071	0.035	0.284	0.277	0.258	0.356
	Obs.	54	45	49	55	58	59	60	62	62	62	62	63
Prices	Cons	-0.001	-0.001	0.001	0.003	0.001	-0.001	-0.003	-0.003	-0.001	-0.004	-0.001	0.001
		(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
	$\Delta comm$	0.001	0.000	0.000	0.002	0.008	0.004	0.014	0.024 **	0.025 **	0.022 **	0.027 **	0.027 **
		(0.003)	(0.002)	(0.002)	(0.004)	(0.006)	(0.007)	(0.010)	(0.011)	(0.011)	(0.011)	(0.012)	(0.013)
	SURP	0.209 ***	0.254 ***	0.224 ***	0.196 ***	0.16 ***	0.169 ***	0.328 ***	0.351 ***	0.347 ***	0.346 ***	0.344 ***	0.347 ***
		(0.035)	(0.011)	(0.013)	(0.041)	(0.048)	(0.056)	(0.094)	(0.083)	(0.081)	(0.080)	(0.079)	(0.077)
	R-Squ.	0.478	0.868	0.781	0.272	0.167	0.147	0.439	0.455	0.42	0.427	0.38	0.340
	Obs.	52	47	49	57	59	57	59	62	63	61	63	64
Real	Cons	0.000	-0.001 *	0.001	0.004 *	0.001	0.000	0.001	0.002	-0.002	0.001	0.001	0.002
		(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
	$\Delta comm$	-0.001	0.001	0.002	0.003	0.009	0.005	0.015	0.02 *	0.018	0.021	0.023	0.025 *
		(0.004)	(0.003)	(0.002)	(0.006)	(0.006)	(0.007)	(0.010)	(0.011)	(0.013)	(0.013)	(0.014)	(0.014)
	SURP	0.218 ***	0.252 ***	0.223 ***	0.191 ***	0.198 ***	0.215 ***	0.214 ***	0.115	0.279 ***	0.278 ***	0.278 ***	0.527 ***
		(0.038)	(0.012)	(0.012)	(0.042)	(0.045)	(0.050)	(0.060)	(0.072)	(0.105)	(0.110)	(0.109)	(0.080)
	R-Squ.	0.441	0.804	0.785	0.304	0.282	0.233	0.216	0.095	0.31	0.252	0.235	0.514
	Obs.	54	49	49	56	57	56	57	60	60	62	62	63
Money	Cons	0.000	-0.001	0.001	0.003	0.002	0.001	0.005	0.005	0.005	0.005	0.006	0.002
		(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
	$\Delta comm$	0.001	-0.002	0.000	0.003	0.003	-0.004	0.004	0.003	0.001	0.001	0.003	0.003
		(0.003)	(0.002)	(0.002)	(0.005)	(0.006)	(0.006)	(0.008)	(0.008)	(0.010)	(0.011)	(0.010)	(0.012)
	SURP	0.217 ***	0.258 ***	0.224 ***	0.197 ***	0.159 ***	0.225 ***	0.143 **	0.137 **	0.495 ***	0.5 ***	0.145 *	0.46 ***
		(0.035)	(0.013)	(0.013)	(0.039)	(0.049)	(0.053)	(0.064)	(0.070)	(0.078)	(0.080)	(0.080)	(0.079)
	R-Squ.	0.441	0.824	0.781	0.275	0.122	0.217	0.037	0.02	0.515	0.495	0.009	0.436
	Obs.	54	49	49	57	60	57	62	62	65	65	62	63

Note, dependent variable: Δr_{t+1}^{M}; Robust standard errors in parenthesis; ***/**/* denote the 1/5/10%-significance level.

distinguish the coefficient of the indicator when inflation was below two percent from times when it was above two percent. The results are reported in Table 2.5. The findings reveal that it indeed matters whether inflation is above or below the target rate of two percent. If it is below, the impact of communication is even higher. If it is above the impact of communication drops dramatically. However, the overall picture stays the same. As before the price indicator seems to be the most prominent topic.

The question remains why markets are reluctant to react to ECB communication in times where inflation is above the ECB's definition of price stability. One could think of two possible explanations. First, arguably the content of the statement becomes less informative. In that case, communication does not contain that much news about the future path of interest rates and the ECB might be more reluctant to give out new information in order to obviate any overreaction. A second possibility is that the ECB remains informative but financial markets do not watch central bankers' lips that closely as contemporary inflation data already contains enough relevant information. If market participant see that inflation is going to hit the relevant threshold of two percent they can infer that the ECB is most likely to step up and fight inflation back into its set limits. Probably both of these reasons are at play.

2.6 Conclusions

In this chapter we investigate the importance of ECB communication for the financial market participants' expectations. We do not only test whether central bank communication affects the term structure of interest rates and thereby the shape of the yield curve but also which paragraphs of the statements contain relevant information and which maturity is affected the most. Five main conclusions arise from this study.

First, confirming previous studies, our findings suggest that central bank communication indeed has an effect on short-term interest rates.

Second, concerning the dynamics of the impact we find that the communication indicator has significant explanatory power for the day to day change in interest rates with maturities from four to twelve months. Hence, we conclude that financial market agents expect the ECB to prepare them for upcoming changes in interest rates at least four months before. This implies that the ECB is not expected to create surprise inflation and financial markets rely on its predictability, which is good news for the evaluation of the effectiveness of ECB communication. However, the exact

Table 2.5: Impact of Communication if HICP> 2

		1M	2M	3M	4M	5M	6M	7M	8M	9M	10M	11M	12M
All	$\Delta comm$	0.005	0.015	0.018 *	0.019 **	0.02 **	0.022 **	0.022 **	0.024 **	0.024 **	0.025 **	0.026 **	0.029 **
		(0.010)	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.011)	(0.012)	(0.012)	(0.013)	(0.013)	(0.014)
	SURP	0.576 ***	0.507 ***	0.47 ***	0.472 ***	0.463 ***	0.467 ***	0.477 ***	0.475 ***	0.479 ***	0.484 ***	0.489 ***	0.489 ***
		(0.053)	(0.051)	(0.050)	(0.050)	(0.051)	(0.056)	(0.060)	(0.064)	(0.067)	(0.069)	(0.071)	(0.074)
	CDHICP2	-0.025 *	-0.027 **	-0.024 **	-0.021 *	-0.018	-0.018	-0.016	-0.016	-0.016	-0.014	-0.014	-0.016
		(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.014)	(0.015)	(0.016)	(0.017)	(0.017)	(0.018)	(0.018)
	R-Squ.	0.7	0.637	0.574	0.579	0.559	0.512	0.486	0.447	0.431	0.422	0.416	0.400
Prices	$\Delta comm$	0.012	0.027 *	0.031 **	0.036 ***	0.038 ***	0.045 ***	0.047 ***	0.049 ***	0.051 ***	0.054 ***	0.057 ***	0.061 ***
		(0.016)	(0.015)	(0.014)	(0.014)	(0.014)	(0.015)	(0.016)	(0.017)	(0.018)	(0.019)	(0.019)	(0.020)
	SURP	0.558 ***	0.484 ***	0.446 ***	0.448 ***	0.439 ***	0.444 ***	0.453 ***	0.45 ***	0.454 ***	0.459 ***	0.465 ***	0.464 ***
		(0.054)	(0.050)	(0.048)	(0.047)	(0.048)	(0.052)	(0.056)	(0.060)	(0.063)	(0.065)	(0.067)	(0.069)
	CDHICP2	-0.013	-0.025	-0.027	-0.029 *	-0.028	-0.036 *	-0.035 *	-0.036 *	-0.038 *	-0.04 *	-0.043 *	-0.048 *
		(0.019)	(0.018)	(0.017)	(0.017)	(0.017)	(0.019)	(0.020)	(0.022)	(0.023)	(0.023)	(0.024)	(0.025)
	R-Squ.	0.669	0.625	0.575	0.594	0.58	0.545	0.521	0.482	0.466	0.459	0.454	0.438
Real	$\Delta comm$	0.003	0.01	0.015	0.017	0.02	0.029	0.029	0.031	0.031	0.035	0.036	0.043 *
		(0.018)	(0.017)	(0.016)	(0.016)	(0.017)	(0.018)	(0.020)	(0.021)	(0.022)	(0.023)	(0.023)	(0.024)
	SURP	0.561 ***	0.484 ***	0.449 ***	0.45 ***	0.443 ***	0.449 ***	0.459 ***	0.457 ***	0.46 ***	0.466 ***	0.471 ***	0.47 ***
		(0.053)	(0.051)	(0.049)	(0.049)	(0.050)	(0.055)	(0.059)	(0.063)	(0.066)	(0.068)	(0.070)	(0.073)
	CDHICP2	-0.024	-0.027	-0.033	-0.03	-0.031	-0.041 *	-0.041	-0.043	-0.043	-0.045	-0.046	-0.051
		(0.023)	(0.022)	(0.022)	(0.021)	(0.022)	(0.024)	(0.026)	(0.028)	(0.029)	(0.030)	(0.031)	(0.032)
	R-Squ.	0.677	0.616	0.558	0.559	0.538	0.498	0.472	0.428	0.411	0.4	0.392	0.378
Money	$\Delta comm$	0.02 *	0.033 ***	0.035 ***	0.037 ***	0.036 ***	0.04 ***	0.04 ***	0.041 ***	0.041 ***	0.043 ***	0.045 ***	0.047 ***
		(0.012)	(0.011)	(0.011)	(0.010)	(0.011)	(0.012)	(0.013)	(0.014)	(0.014)	(0.015)	(0.015)	(0.016)
	SURP	0.565 ***	0.493 ***	0.457 ***	0.461 ***	0.453 ***	0.457 ***	0.469 ***	0.467 ***	0.473 ***	0.479 ***	0.485 ***	0.484 ***
		(0.053)	(0.048)	(0.046)	(0.045)	(0.047)	(0.051)	(0.055)	(0.060)	(0.062)	(0.065)	(0.067)	(0.069)
	CDHICP2	-0.02	-0.032 **	-0.035 ***	-0.039 ***	-0.04 ***	-0.045 ***	-0.046 ***	-0.049 ***	-0.052 ***	-0.055 ***	-0.058 ***	-0.062 ***
		(0.017)	(0.015)	(0.015)	(0.014)	(0.015)	(0.016)	(0.018)	(0.019)	(0.020)	(0.021)	(0.021)	(0.022)
	R-Squ.	0.681	0.652	0.607	0.621	0.598	0.555	0.526	0.481	0.464	0.454	0.449	0.434
	Obs.	67	67	67	67	67	67	67	67	67	67	67	67

Note, dependent variable: Δr_{t+1}^{M}; Robust standard errors in parenthesis; ***/**/* denote the 1/5/10%-significance level.

timing of a decision is less foreseeable: financial markets expectations show that the change in the policy controlled interest rate is expected to be conducted the soonest at four months and the latest within the coming twelve months, which is a range of eight to nine months.

Third, evaluating the impact of the contents of the statements by topic, the comments of the ECB on prices are the part financial markets react most strongly to, whereas the ECB's interpretation of developments in the real economy and the monetary aggregates seems to be mostly expected or not of concern for financial market agents. This reveals that the ECB's interpretation about current and expectations about future price developments are unforeseeable and important for financial market agents and therefore affects asset prices via changes in financial market expectations. This is not the case for the interpretation and expectation about real economic developments and variances of monetary aggregates. Hence, the topic of communication is of major importance for analyzing the effect of ECB wording. This is a finding that will be taken into account in the upcoming two chapters where we consider different proxies to capture expectations.

Fourth, communication is much more informative during periods with inflation below two percent. If inflation rises above the two percent threshold, the ECB's communication affects future interest rates to a lesser amount.

Finally, we can conclude that the ECB is found to be *credible* as financial market agents believe in the content of its statements. With respect to *transparency*, we can observe some surprise in the effect of the main refinancing rate on expectations, independent of the news contained in the statement. This shows that the ECB is credible but still the exact timing and the magnitude of interest rate changes are not completely anticipated by financial markets.

CHAPTER 3

The High-Frequency Response of the EUR-US Dollar Exchange Rate to ECB Monetary Policy Announcements

3.1 Introduction

In this chapter we investigate the high-frequency impact of the European Central Bank's (ECB's) monetary policy announcements on the EUR-US Dollar (EUR-$) exchange rate throughout the 89 meeting days of the ECB governing council within the period 01/1999–10/2006. A meeting day consists of the announcement of the next key interest rate via a press release at 13.45 CET and the press conference which starts at 14.30 CET with the introductory statement – containing a detailed assessment of the economic situation and future prospects – and ends with a question and answer session (Q&A). All three events are of major importance. First, the reaction of the market participants to the pure interest rate announcement depends on how well the public anticipated the policymakers' decision as well as on how the public interprets this signal, and therefore on how successful the policymaker was in guiding market expectations. Second, the market participants' assessment of the policymakers' communication in the introductory statement is a relevant

This Chapter is based on Conrad and Lamla (2007).

ingredient to expectation formation and hence matters for the movement in the exchange rate.[1] Finally, the discussion in the Q&A session allows to clarify certain points mentioned in the statement or being of concern for the market participants who in turn might adjust expectations and thus move the exchange rate. An econometric approach which allows to trace the effects of the pure announcement released at 13.45, the introductory statement beginning at 14.30 and the Q&A following thereafter requires two ingredients: an appropriate modelling of the intraday high-frequency movements of the EUR-$ exchange rate and a meaningful quantification of the ECB's communication.

The building blocks of our analysis are derived from two strands of existing literature. One strand is concerned with the high-frequency modeling of exchange rate returns with a particular emphasis on the movements in the second conditional moment. In a seminal article, Andersen and Bollerslev (1997) show that high-frequency exchange rate returns are characterized by a strong intraday periodicity in their conditional variance. From their study it is evident, that the "estimation and extraction of the intraday periodic component is both feasible and indispensable for a meaningful intraday dynamic analysis" (Andersen and Bollerslev, 1997, p. 116). Along these lines, Andersen and Bollerslev (1998) analyze high-frequency Deutsche Mark-US Dollar returns and reveal that the volatility process can be naturally separated into three components: (i) a deterministic periodic component (including day-of-the-week and calender effects), (ii) announcement effects and (iii) ARCH effects. Following the articles of Andersen and Bollerslev (1997) and Andersen and Bollerslev (1998) it has become a standard approach to estimate the deterministic periodic component by assuming that the intraday volatility pattern is best described by a flexible Fourier form (FFF). Announcement effects are either estimated directly within the FFF regression or in a two step procedure by investigating the filtered return series, i.e. the original return series divided by the FFF estimated seasonal component. This second approach is employed by e.g. Baillie et al. (2000) and Han (2004). Finally, Andersen et al. (2003) shift the focus of attention to the reaction of the conditional mean of exchange rate returns in response to macroeconomic announcements. While the volatility response is at least partly driven by the pure fact that an announcement is released, the conditional mean reacts only to surprise news, i.e. a deviation of the released figures from what market participants expected. In particular, the impact of monetary policy announcements concerning interest rate decisions on exchange rates has recently received great attention. Among others, the studies of Faust et al. (2007) and Kearns and Manners (2006) point towards a positive

[1] E.g., market participants try to judge upon how "hawkish" or "dovish" a central bank acts and to infer how seriously the central bank aims at ensuring price stability.

relationship between unexpected interest rate changes and exchange rate movements: exchange rates react to an unforeseen monetary tightening (easing) by appreciating (depreciating).

This brings us to the second strand of literature that needs to be considered for a meaningful analysis. At the heart of this literature is the attempt to measure the quantitative implications of central bank communication on exchange rates and interest rates. Jansen and de Haan (2005) discuss the role of the ECB's statements to "speak up" the EUR and discover only a volatility effect using daily exchange rate data. Switching to high-frequency, Jansen and de Haan (2007) find both a mean and a volatility effect. However, the mean effect is comparatively small and rather short-lived. Fratzscher (2004) provides evidence that oral interventions effect the mean as well as the volatility and reports that during actual interventions oral interventions reduce volatility while the actual interventions themselves increase the movement of exchange rates. Similarly, Beine et al. (2004) notice that comments during official exchange rate interventions were partially effective. While these studies use dummy variables to measure communication, recent studies on interest rates create communication indicators. Heinemann and Ullrich (2007) construct an indicator based on specific code words, while Berger et al. (2006a) propose a content based indicator. With respect to the EUR-$ exchange rate Siklos and Bohl (2006) capture the impact of press releases of the ECB commenting on specific developments in the real sector. Despite this research effort, there is no study which tests for the impact of the ECB's key communication instrument, namely the press conference, on the EUR-$ exchange rate. This is remarkable because there has been increasing interest in studying the impact of this key communication instrument on interest rates. For example, Ehrmann and Fratzscher (2007b) investigate the effects of the ECB's press conference on the 3-month Euribor futures rates. They report that the press conference can have an even stronger effect than the press release of the interest rate decision.

Our analysis contributes to the existing literature in several ways. We test for the impact of the interest rate announcement, the introductory statement as well as the Q&A session on the mean and the volatility of the EUR-$ exchange rate by using a long time span (01/1999–10/2006) of five-minute intraday data. The major advantage of employing high-frequency rather than daily data is that we can directly monitor the impact of all three events on the market in real time and bypass problems with regards to causality and identification. In that respect the ECB serves as an excellent example. First, all decisions discussed at the governing council meeting are made public and explained within one day. Second, the content of the introductory statement is not released in one shot but read to the public and the expert group. To the best of our knowledge, we are the first to provide a statistical framework that allows to simultaneously trace the effects of all three

events on the EUR-$ exchange rate and at the same time controls for interdependencies between those events.

As mentioned above, the usage of intraday data requires an econometric methodology which allows to separate the announcements effects from the typical intraday volatility pattern. In our setup, we have to deal with the additional complication that right at the beginning of the introductory statement at 14.30 there are major macroeconomic announcements in the U.S. In a first step, we deseasonalize the high-frequency returns using a control sample from which both the intraday seasonal pattern and the U.S. announcement effects are extracted. For this purpose, we develop a new procedure based on nonparametric kernel smoothing techniques. For the simultaneous analysis of the effects of the press release and the press conference this smoothing step is essential. While at 13.45 market volatility is usually low, it is much higher at 14.30 because of the opening of the U.S. markets at 14.00 and the U.S. announcements at 14.30. Our approach guarantees that this regular increase in volatility is not attributed to the press conference.

Since the filtered absolute returns reveal a clear pattern of long memory and persistence, a model for the conditional variance of the exchange rate should take into account this property. We estimate an AR-FIGARCH specification for the filtered five-minutes returns whereby we control for surprise interest rate announcements, the content of the press conference as well as the Q&A session in both the mean and the variance. Our surprise measure for the interest change is taken from the Reuters business surveys. To assess the impact of the press conference, we rely on a new communication indicator which explicitly takes into account the content of each sentence. We have spawn this new communication indicator based on a coding of the content of the introductory statement provided by a media research institute. The indicator captures information on expected developments in major policy-relevant areas like inflation, the exchange rate, the real economy as well as monetary aggregates.

We show that a surprise in the released interest rate decision leads to significant movements in the level and volatility of the EUR-$ exchange rate at 13.50 and the following thirty-minutes. More specifically, we find an asymmetry in the response to positive and negative interest rate surprises. While the exchange rate adjusts to positive interest rate surprises immediately after the press release, reactions to negative surprises are partly postponed to the period of the introductory statement. Market participants seem to evaluate negative surprises in connection with the assessment of the ECB. Moreover, there are important interactions between the interest rate surprise and the direction of the interest rate change. For example, our results are very much in line with the

'practitioners claim' that prices react more strongly to bad news in good times than to bad news in bad times.

Concerning the introductory statement, our main finding is that financial markets react most strongly to communication about future price developments which effects the mean and the volatility. In line with the predictions of Clarida and Waldman (2007), market participants seem to use the new information about future inflation rates to update their beliefs concerning the ECB's future interest rate setting. In addition, if the communication was preceded by a (negative) interest rate surprise, the introductory statement serves as a tool for explaining the recent decision. Explicit statements on the expected development of the exchange rate effect the mean but not the volatility of the exchange rate. The other topics (real economy, monetary aggregates) appear to be irrelevant for the reaction of the exchange rate. Finally, by splitting the sample, we find evidence that the introductory statement gained importance in recent times. While the Q&A itself adds no systematically important information to the markets it complements the earlier announced decision of the ECB.

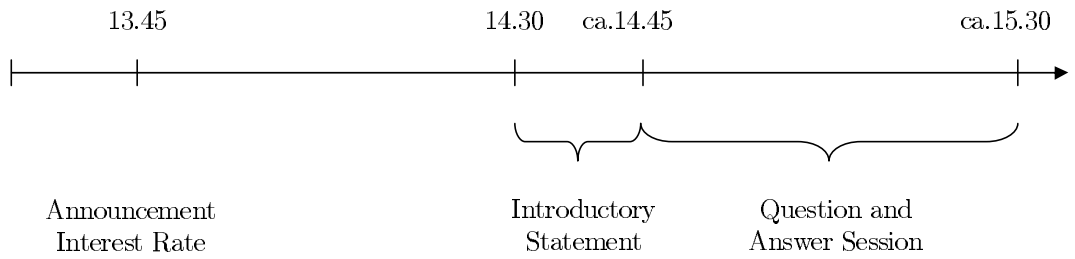
In summary, both the ECB's policy decision on the target interest rate as well as its communication impact the EUR-$ exchange rate in an order of magnitude which is statistically and economically important.

The remainder of this chapter is organized as follows. Section 3.2 briefly elaborates on the linkages between ECB announcements and exchange rate movements. In Section 3.3 we analyze the time series properties of the five-minute EUR-$ exchange rate data and suggest a new methodology for extracting the intraday seasonal pattern. Moreover, we introduce the Reuters data on market expectations and the ECB communication indices. Section 3.4 lays out the properties of the AR-FIGARCH model which is the workhorse for our empirical analysis conducted in Section 3.5. Finally, Section 3.6 concludes.

3.2 ECB Announcement Days and Exchange Rate Movements

In this section we will contend the expected relationship between the different types of announcements and their impact on the exchange rate. Figure 3.1 displays the timing of the press release, the press conference and the Q&A session during ECB announcement days. At 13.45 the interest rate decision is announced via a press release. This press release contains solely the interest rate

Figure 3.1: Timing of the Press Release, the Introductory Statement and the Q&A Session during ECB Announcement Days.



decision without any further explanation. From 14.30 onwards the introductory statement is held by the ECB's President and the Vice-President which is then followed by the Q&A session.[2] The end of the introductory statement is not a priori fixed in time as it depends on the judgment of the governing council to what extent the relevant topics are addressed. On average it ends around 14.45. The introductory statement is, besides the Monthly Bulletin, the most important communication instrument and comprises a policy-relevant assessment of the governing council on the current standing of the economy, the outlook for future prices and the interest path. As its text is based on a wording agreed upon by all council members it is a valuable source of information. The Q&A session that follows thereafter provides a platform for media representatives around the world for further explanation of the monetary policy decision.

The direction in which an interest rate surprise will move the exchange rate is a priori uncertain and depends on the market participants beliefs about the model of exchange rate determination.[3] Interest rate parity and arbitrage opportunities imply an appreciation of the home currency due to an unexpected monetary tightening. Hence, the surprise announcement of an increasing interest rate should lead to an appreciation of the home currency relative to the foreign currency. However,

[2]The introductory statement has a clear structure. After welcoming the attendants, the ECB's President repeats the interest rate decision and provides a general assessment, which is then followed by a detailed discussion of developments in the real economy, in prices, in the exchange rate, monetary developments and a summary. Before May 2003 the discussion of monetary developments preceded the discussion of the real economy.

[3]Of course, also anticipated changes of the interest rate can have an effect on the exchange rate. This effect, however, should be already priced into the exchange rate at the announcement of the decision.

this need not necessarily to be the case. One aspect, for instance, are differences in the reaction in the short to medium and long-term horizon driven by e.g. Dornbush's overshooting model. Another reason for a movement of the exchange rate that does not match this pattern are expectations about future developments. As Ehrmann and Fratzscher (2005b) argue an unexpected easing of monetary policy might signal to the public an economic upturn associated with high economic activity as well as rising asset prices in the future and consequently imply that the home currency appreciates and not depreciates. Similarly, it might happen that an unexpected monetary tightening appears to have no effect on the exchange rate, while it indeed prevented the exchange rate from a further depreciation. Finally, technical trading may serve as an explanation. Agents might bet in front of central bank announcements against or in favor of an exchange rate movement which might swamp the effect of the announced interest rate movement afterwards.

The linkage between the ECB's press conference and the exchange rate has not yet been tackled explicitly in the economic literature. However, attempts were made to discover the impact of ECB announcements targeting the exchange rate. See for instance Jansen and de Haan (2007) or Beine et al. (2004) who test how ECB announcements concerning exchange rate interventions and the assessment of an undervalued/overvalued currency were perceived by the market. As noted earlier the interpretation matters. Following the argumentation in Almeida et al. (1998), communication on rising future inflation could lead to a depreciation of the EUR if the ECB reaction function assigns relatively low weight to the level of inflation. On the other hand, if the central bank reaction function shows a strong preference for low inflation, the same news should induce an appreciation of the EUR. Similarly, Clarida and Waldman (2007) argue that bad news of rising inflation could be good news for the exchange rate markets. If the corresponding central bank follows a Taylor-type monetary policy rule, news about rising inflation should result in a monetary tightening, which in turn implies a higher demand for the national currency and thus an appreciation.

So far, no study provided empirical evidence on the implications of the Q&A session. Its main purpose is not to add new information but to clarify the intentions and the assessments of the decision-makers. Thus, we expect no impact of the Q&A session itself. Nevertheless, the Q&A session could be relevant if we condition on the preceding actions taken.

3.3 Data

3.3.1 Exchange Rate Data

Since the ECB's governing council meetings and the respective three events usually take place on Thursdays and it is well known that the intraday volatility pattern varies across the days of the week, we employ for our analysis only high-frequency EUR-$ exchange rate data stemming from Thursdays.[4] Our original sample consists of irregularly spaced tick-by-tick quotes of the EUR-$ exchange rate for all 417 Thursdays in the period January 1999 to October 2006 obtained from Olsen and Associates.[5] Each quote contains a bid and an ask price along with the time stamp to the nearest second. Taking the immediately preceding and following quotation at the end of each five minute interval we obtain the log price by linearly interpolating the average of the log bid and the log ask at each five-minute mark. Five-minute returns are then constructed as the change in these five-minute log prices. The returns are denoted by $R_{k,n}$, $k = 1, \ldots, K$ and $n = 1, \ldots, N$, where K is the number of days in our sample and $N = 288$ is the number of five-minute intervals per day. Among all Thursdays there are 89 ECB monetary policy decision days. The remaining "non-announcement" days will serve as control days. The standard summary statistics (not reported) for the ECB announcement days and the control days are virtually identical. The sample mean of the five-minute returns is indistinguishable from zero at any standard significance level. While the skewness is not significantly different from zero, there is evidence for excess kurtosis significantly larger than three. Hence, the five-minute return distribution is symmetric around zero but non Gaussian which is also confirmed by the Jarque-Bera statistic. As often reported for high-frequency data, there is some evidence of serial correlation for low lags in the five-minute EUR-$ returns, possibly due to microstructure effects. No significant correlations are found for higher lags. In sharp contrast, the squared and absolute returns are highly correlated even for long lags. In the following we will analyze these intertemporal dependencies in the absolute returns in more detail.

The average absolute returns over the five-minute intervals for the 328 control days (solid) and the 89 announcement days (dashed) are shown in Figure 3.2. From this figure it is clear that the absolute return series display a pronounced intraday volatility pattern. At 1.00 volatility begins to increase with the opening of the Singapore and Hong Kong markets which are followed by the

[4] There are only four exceptions from this rule. On those four days the decision was made on a Wednesday.

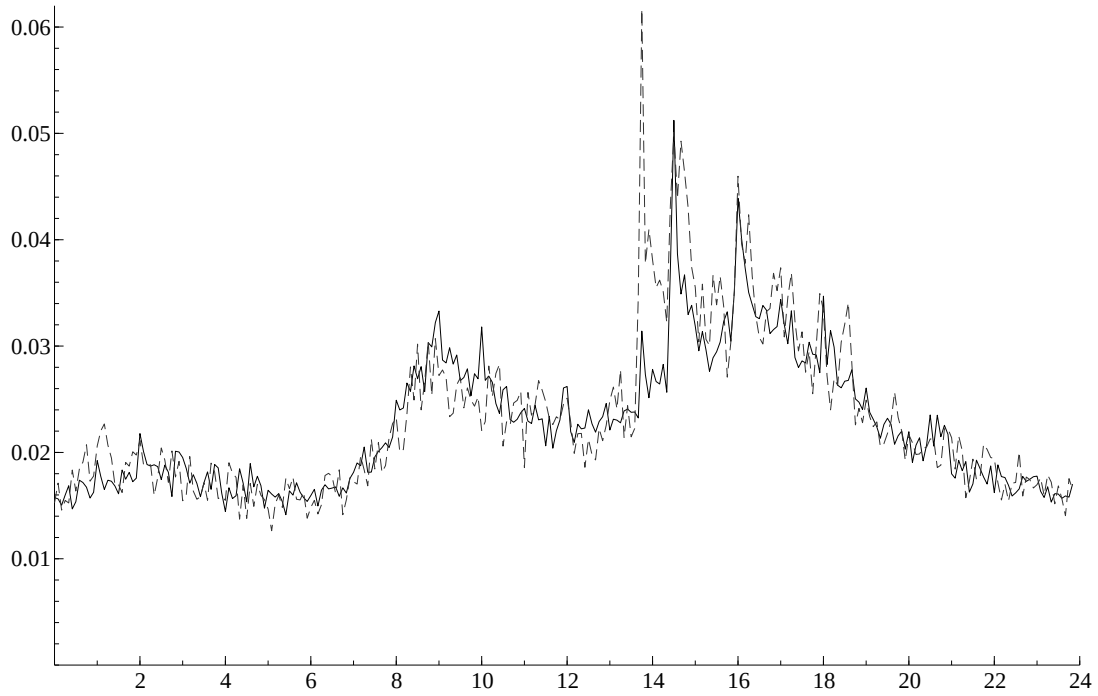
[5] We define the exchange rate such that an upward movement implies an appreciation of the EUR relative to the U.S. Dollar.

Tokyo market one hour later and by the Sydney market two hours later. The decline in volatility around 4.00 to 5.30 reflects the lunch hour in the Tokyo and Hong Kong markets. Volatility then sharply increases with the opening of the European markets around 8.00 and tails off again with European lunch time around 12.00. The U.S. markets open at 14.00. Between 14.00 and 17.00 both the European and American markets are open simultaneously and volatility is highest during the day. Finally, after the closing of the European markets around 17.00 volatility starts to decline monotonically back to the level associated with the Pacific segment. The solid line reveals two volatility spikes during the trading day. A first one at 14.35 and a second one at 16.05. Both volatility spikes are induced by major macroeconomic news announcements which take place in the U.S. at 14.30 and 16.00.[6] The dashed line which is associated with the ECB announcement days reveals an intraday volatility pattern which is almost identical to the one of the control days for most of the trading day. However, exactly at the timing of the ECB press release and during the press conference one can observe distinct differences.

Figure 3.3 renders for a more detailed view on the important time period between 13.00 – 16.00. The solid line represents the difference between the average absolute five-minute EUR-$ returns on announcement and control days. Clearly, we observe a sharp increase in volatility at 13.50. Since neither in the U.S. nor in Europe any other macroeconomic news is released at 13.45, the dramatic increase in volatility at 13.50 must reflect how market participants process the news associated with the ECB's monetary policy decision launched by the press release. This increase in volatility has no counterpart on the control days. At 14.35 the difference in the two volatilities is basically zero. This is not surprising, since the ECB's introductory statement starts with welcoming all the participants and a reiteration of the policy decision, and hence it should not reveal news to the market in the first few minutes. Our interpretation is therefore that at 14.35 both announcement and control days are dominated by the macroeconomic announcements released in the U.S., resulting in the zero difference of the volatilities. However, while on control days the volatility immediately falls back at 14.40, there is a second spike at 14.45 on the announcements days reflecting the new information made public by the communication during the press conference. From 14.45 onwards, the difference in the volatilities of announcement and control days is again declining, indicating that after the finishing of the ECB press conference there is no systematic difference in the two types of days.

[6] In particular, the announcements at 14.30 consist of releases on GDP, Producer Price Index, personal income, jobless claims, productivity, non-farm payrolls, etc.

Figure 3.2: Average Absolute Five-Minute EUR-$ Returns for each Five-Minute Interval during the Trading Day.



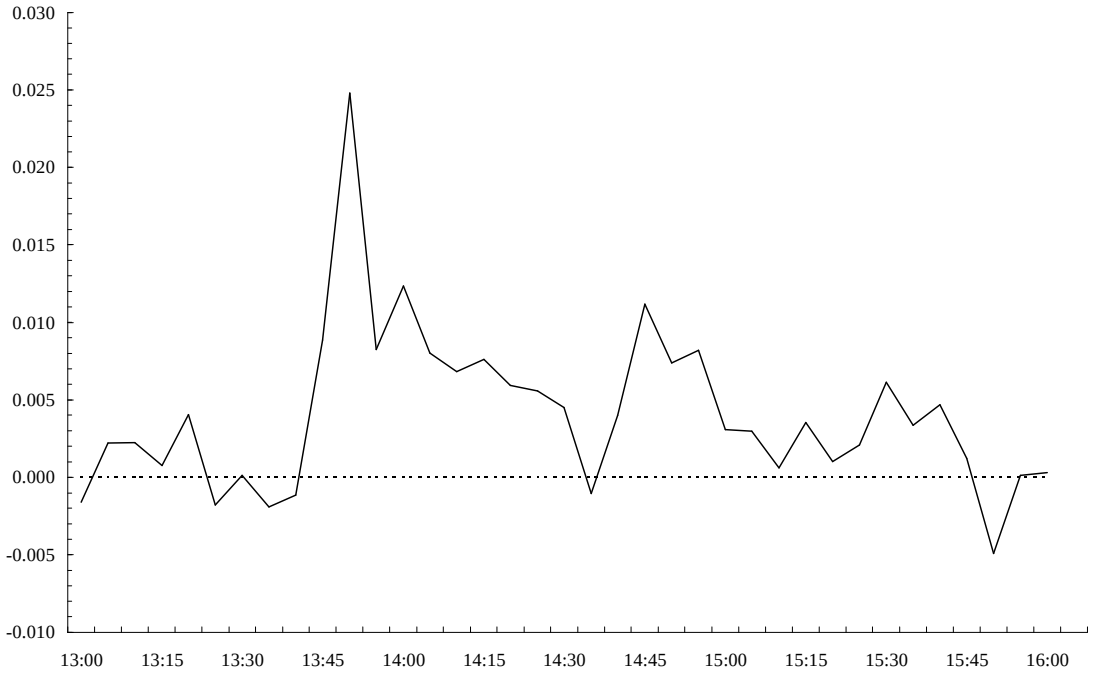
Solid line: all control days, dashed line: announcement days; X-axis: timeline(24h).

Clearly, the systematic movements in the daily volatility pattern of the EUR-$ exchange rate should have consequences for the dependencies between lagged absolute returns. The autocorrelation functions of the absolute return series over one (left) and five (right) trading days are shown in Figure 3.4. Similarly, as observed by Andersen and Bollerslev (1997), the sample autocorrelations are characterized by a "distorted U-shape" behavior induced by the strong intraday pattern discussed above. Hence, as argued in Andersen and Bollerslev (1997) it is indispensable for any meaningful analysis employing the intraday returns to first estimate and extract the intraday periodic component of return volatility.

3.3.2 Modeling the Periodic Intraday Pattern

In this section we propose a new method for filtering out the periodic intraday seasonal component from the high-frequency return series. The procedure is based on a nonparametric kernel estimate

Figure 3.3: Difference between the Average Absolute Five-Minute EUR-$ Returns on Announcement and Control Days in the Time Period 13.00 – 16.00.

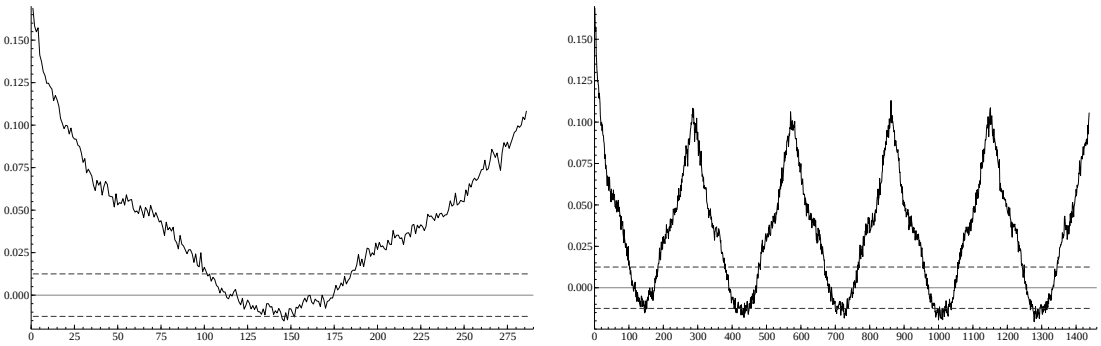


of the intraday volatility pattern and – in contrast to previous approaches – does not require the subjective choice of potentially important points in time and the length of their effect on volatility. The typical pattern of a Thursday including the U.S. announcement effects will be extracted from the control days, which have – apart from the effects of the ECB announcements – the same intraday seasonal pattern as the announcement days. By doing so, the proposed procedure takes into account intraday seasonality but at the same time ensures that we do not explain away what we are actually interested in.

As in Andersen and Bollerslev (1997), we assume the following structure for the intraday returns

$$R_{k,n} = \mathbf{E}(R_{k,n}) + \frac{\sqrt{h_k} s_n Z_{k,n}}{\sqrt{N}}, \tag{3.1}$$

Figure 3.4: Sample Autocorrelation Functions of Five-Minute Absolute EUR-$ Returns for one Day (Left) and Five Days (Right).



Dashed lines are 95% confidence bands.

where $\mathbf{E}(R_{k,n})$ denotes the unconditional expectation of the five-minute returns, h_k is the conditional variance of day k and s_n a deterministic periodic component for the n-th intraday interval. The innovations $Z_{k,n}$ are assumed to be independently and identically distributed ($i.i.d.$) with mean zero and unit variance. Moreover, we assume that the $Z_{k,n}$ are independent of h_k. Note, that Andersen and Bollerslev (1997) allow the periodic component s_n also to depend on day k. While this is important when one has to deal with day-of-the-week effects, it is unnecessary in our context since we consider Thursdays only.

Next, the aim is to obtain an estimate of the seasonal component s_n. As suggested by Andersen and Bollerslev (1998) we estimate the seasonal component from a regression using a log-transformation of equation (3.1) which is more robust to extreme outliers in the five-minute return series than a regression in terms of, say $R_{k,n}^2$. Equation (3.1) can be rewritten as

$$\begin{aligned} r_{k,n} &\equiv 2\log(|R_{k,n} - \mathbf{E}(R_{k,n})|) - \log(h_k) + \log(N) = \log(s_n^2) + \log(Z_{k,n}^2) \\ &= f(n) + u_{k,n}, \end{aligned} \tag{3.2}$$

with $i.i.d.$ mean zero error term $u_{k,n} \equiv \log(Z_{k,n}^2) - \mathbf{E}(\log(Z_{k,n}^2))$. An estimable version of equation (3.2) is obtained by replacing $\mathbf{E}(R_{k,n})$ and h_k by suitable estimates. While $\mathbf{E}(R_{k,n})$ can be naturally estimated with the sample mean of the five-minute returns, there are several potential candidates for an estimate $\widehat{h}_k$ of h_k. Andersen and Bollerslev (1997) estimate a GARCH model on the daily return series and then substitute h_k by the fitted conditional variance series. However, this approach has the disadvantage that the daily conditional variance is modeled as a slowly

varying function of past residuals and past conditional variances. In particular, it captures sharp increases in volatility only with some time lag, since a sudden increase in volatility on a certain day will not effect the GARCH estimated conditional variance for that day, but for the following day and onwards. Alternatively, we estimate h_k by the realized volatility of the respective day, i.e. by $\widehat{h}_k = \sum_{n=1}^{N} R_{k,n}^2$, which exploits contemporaneous intraday information. In contrast to the fitted conditional variances from a parametric GARCH model which may suffer from misspecification error, the realized volatility results in a consistent estimate of the true h_k.

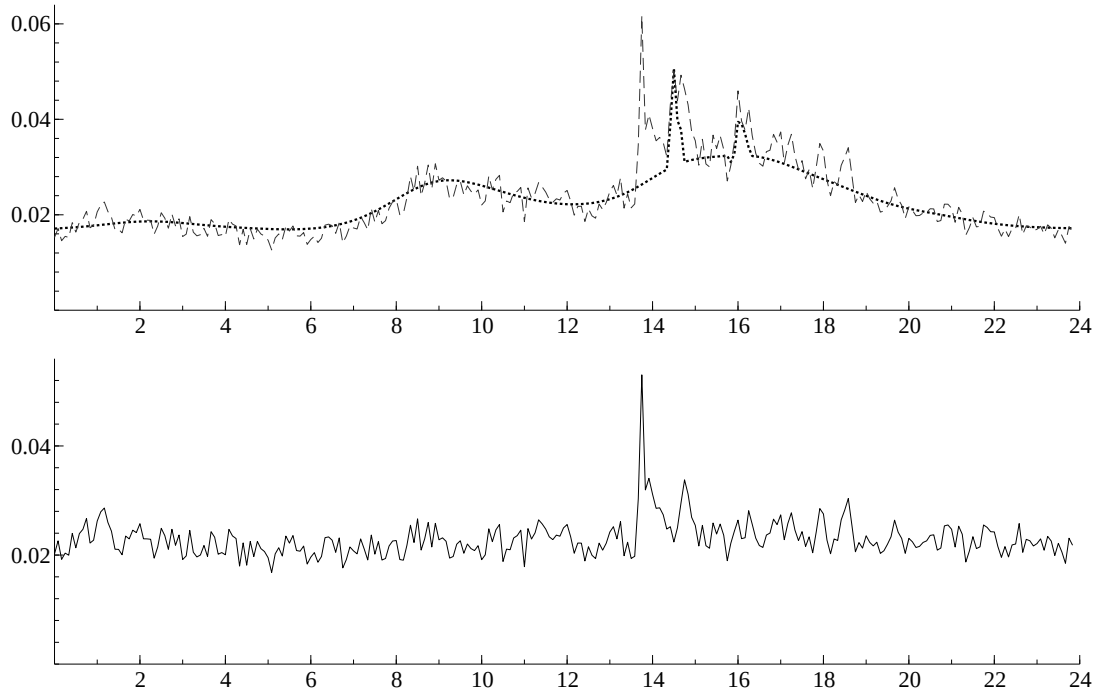
Replacing $\mathbf{E}(R_{k,n})$ and h_k by their estimates leads to a series $\widehat{r}_{t,n}$. The Andersen and Bollerslev (1997) approach assumes that $f(n)$ can be approximated by a parametric function $f(n|\theta)$ which is specified as a flexible Fourier form with trigonometric terms that obey a strict periodicity of one day and additional dummy variables capturing announcement effects. In their framework an estimate of the seasonal component can be obtained by regressing $\widehat{r}_{k,n}$ on $f(n|\theta)$ by ordinary least squares. This in particular requires first a subjective election of possibly important announcements and second the knowledge of the exact timing of each particular announcement. Moreover, one has to specify for how long a particular announcement effects the conditional variance.

We suggest an alternative approach based on nonparametric kernel smoothing. To obtain an estimate of the seasonal component we regress $\widehat{r}_{k,n}$ non-parametrically on a grid $x = 1, \ldots, N$ of five-minute intervals over the trading day. This can be naturally done by using a Naradaya-Watson kernel estimator of $f(x)$ which is given by

$$\widehat{f}_b(x) = \frac{\sum_{k=1}^{K} \sum_{n=1}^{N} K_b(n-x)\widehat{r}_{k,n}}{K \sum_{n=1}^{N} K_b(n-x)}, \tag{3.3}$$

where $K_b(\cdot) = b^{-1}K(\cdot/b)$ with K being a kernel function and b the bandwidth parameter. Since the main purpose of our research is to explain the movements in the volatility of the EUR-$ exchange rate on ECB announcement days by exogenous variables we apply the procedure to the control days only. Thereby, we extract the shape of the *typical* seasonal component of a Thursday including U.S. announcement effects but not the effects due to ECB announcements. In a first step we choose a global bandwidth b_g by cross-validation. This results in an accurate estimate of the overall intraday volatility pattern. In order to accommodate the effects of the U.S. announcements we locally apply a smaller bandwidth $b_l < b_g$ chosen according to the rule suggested in Lepski et al. (1997). This approach allows for an endogenous search for 'important' announcements. Moreover, the data determines how long those announcements effect the volatility. The upper part

Figure 3.5: Nonparametric Fit of the Intraday Seasonality and Filtered Average Absolute Returns



The upper figure graphs the nonparametric fit to the intraday seasonality of all control days (dotted line) together with the average absolute returns for all ECB announcement days (dashed line). The lower figure graphs the filtered average absolute returns for all ECB announcement days.

of Figure 3.5 graphs the fit $\widehat{f}(x)$ across the 24-hour trading day in comparison to the average absolute returns of the ECB announcement days.[7] Finally, the filtered five-minutes returns are obtained as $\widetilde{R}_{k,n} \equiv R_{k,n}/\widehat{s}_n$, whereby the $\widehat{s}_n$ are standardized such that $1/N \sum_{n=1}^{N} \widehat{s}_n = 1$. The filtered returns are plotted in the lower part of Figure 3.5. Clearly, both the intraday volatility pattern as well as the effects due to U.S. announcements have been removed, while ECB announcement effects have been preserved.

[7] To compare the estimates with the absolute returns we have to convert the intraday seasonality pattern through the transformation

$$|R_{k,n} - \mathbf{E}(R_{k,n})| = \frac{\sqrt{h_k}\exp\left(f(n)/2\right)\exp\left(u_{k,n}/2\right)}{\sqrt{N}}.$$

The autocorrelation function of the absolute filtered return series is plotted in Figure 3.6. In comparison to Figure 3.4 (right) which depicts the autocorrelation function of the unfiltered return series, the proposed procedure does its job very well, resulting in a dramatic reduction in the periodic pattern. Interestingly, the autocorrelations of the absolute values of the filtered series initially decay rapidly, but are characterized by an extremely slow rate of decay thereafter. This type of decay is typical for long memory processes associated with autocorrelations decaying as j^{2d-1}, where d denotes the order of fractional integration. To illustrate this point we run the regression $\log(\hat{\rho}_j) = c_0 + c_1 \log(j) + u_j$, $j = 5, 6, \ldots, 1440$, where $\hat{\rho}_j$ denotes the sample autocorrelation of the absolute filtered five-minute returns. Figure 3.6 shows that the rate of hyperbolic decay implied by the estimated persistence parameter of $\widehat{d} = (\widehat{c}_1 + 1)/2 = 0.41$ fits very well with the autocorrelations of the absolute filtered returns. Hence, an appropriate model for the conditional variance must allow for such long memory behavior. This requirement clearly rules out the class of short memory GARCH models which are characterized by exponentially decaying autocorrelations.

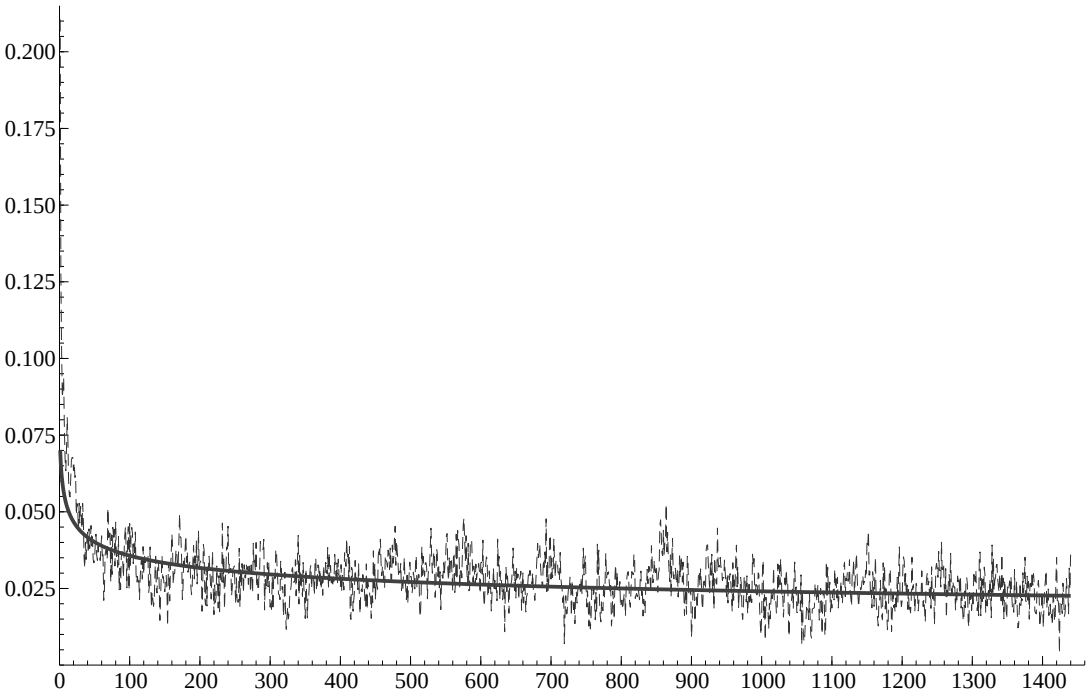
3.3.3 Reuters Data on Surprises

In order to construct our surprise measure with respect to the monetary policy decision we utilize the Reuters survey of professional forecasters. The surprise measure is constructed as follows: one week ahead of the governing council meeting Reuters asks up to 80 financial analysts about their expectations concerning the key interest rate being decided upon during the central bank meeting. Out of this questionnaire a monetary policy surprise is calculated as the mean respectively the median of the difference between the interest rate announced in the press release on the meeting day and the ex-ante expectations of the analysts. In the following, we will denote the mean surprise measure by $sr_{k,13.45}$. To be able to detect asymmetric responses of the exchange rate to positive and negative surprises, we split $sr_{k,13.45}$ into $sr^{+}_{k,13.45}$ and $sr^{-}_{k,13.45}$.

In comparison to our measure, previous studies employed a less explicit instrument to control for a surprise in the interest rate announcement. Zettelmeyer (2004) as well as Kearns and Manners (2006) propose to use the change in the 1-month respectively 3-month treasury bill interest rates. Clearly, this is a much more indirect measure of a surprise to the markets. Moreover, it may be distorted by market movements not related to the ECB decision.[8]

[8] There may have been, for instance, a trend in the interest rate movement.

Figure 3.6: Sample Autocorrelation Function of the Filtered Absolute Return Series (Dashed) and Fitted Hyperbolic Decay (Bold).



Sample autocorrelation function covering five days.

3.3.4 ECB Communication Indicator

To capture the impact of communication, the introductory statements have to be transformed into quantitative measures. Reviewing the earlier indices generated to portray the content of the wording we decided to spawn a new index. An appealing feature of this index is that it measures the content of the press conference, but is not generated by simply counting and valuing signal words as done in earlier studies. The new indicator is based on a coding of each introductory statement provided by the media research institute Mediatenor, which was commissioned by the KOF Swiss Economic Institute. Mediatenor has a long track record in handling press releases and no self interest in a specific outcome. We aggregate the coding into an index in a sensible way explained later in the text.

Most of the empirical studies that focus on the impact of communication events such as central bankers speeches or central bank statements use binary proxies (i.e. if there was a statement

or not). This, however, only allows to analyze the effect of a statement, no matter what the content is. In reality financial markets closely watch central bankers lips and analyze their speeches thoroughly. Therefore, a measure that allows us to quantify the *content* of these statements is of major importance.

Some recent studies like Heinemann and Ullrich (2007) identify "code words" from ECB statements or publications to construct indicators for "hawkishness" in ECB statements. The advantage of such approaches is that they are relatively mechanical in quantifying ECB communication and are therefore in principle reproducible.[9] However, financial market agents, especially the so called "ECB Watchers", exactly analyze the statements and pay attention to the specific content of these statements. Moreover, there is no distinction of whether a "code word" such as "upside risk" is related to developments in the real economy, in prices or in money growth. Allowing for such distinctions might be of major importance since the ECB's interpretation on developments in a certain sector may be completely ignored by financial markets, while they react strongly to interpretations on other sectors. The mechanical quantification by only counting certain expressions therefore disregards too much information relevant for our purpose. Incorporating the entire content and allowing for different dimensions – as is done in our indicator – seems to be a more appropriate solution. In a recent study Berger et al. (2006a) construct an ECB communication indicator which is based on an interpretation of the introductory statement and thereby tries to capture not only the obvious content but also allows for a "reading between the lines". The main drawback of their index is that it lacks objectivity and reproducibility, since the quantification mechanism is based on the opinion of a few selected economists.

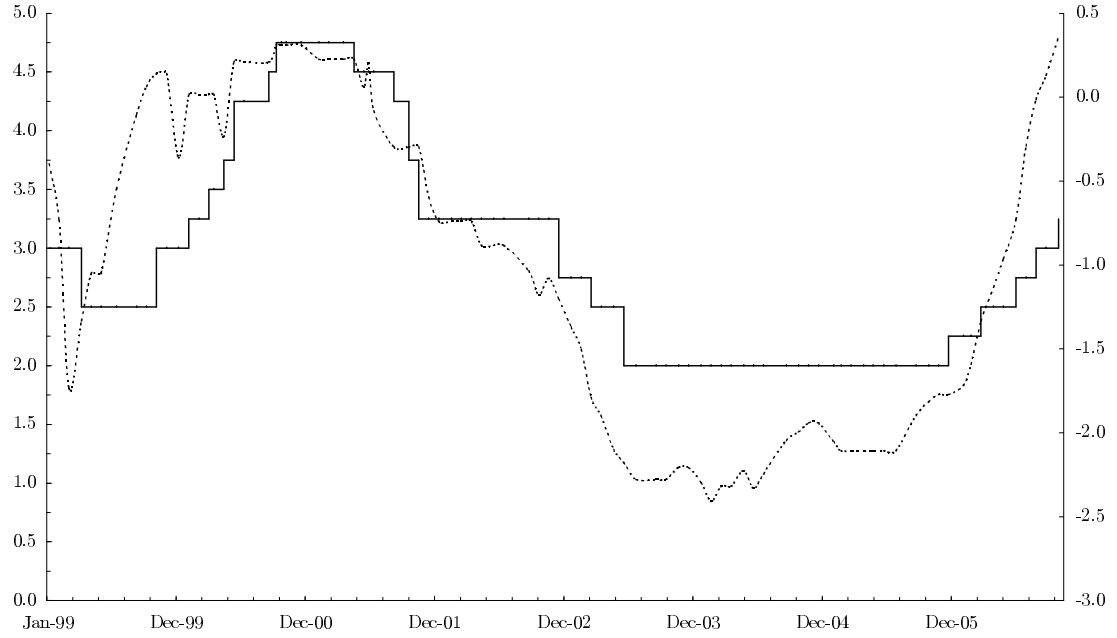
To capture the content and to guarantee a high degree of objectivity and reproducibility we let Mediatenor, a media research institute, code the introductory statements.[10] Mediatenor surveys the content of the introductory statements from 01/1999 until 10/2006. Overall 89 statements have been coded. Each sentence has been analyzed in a variety of ways.[11] For our purpose we extract information about future prices, the real economy, the exchange rate and money growth. Obviously, these sectors correspond to the topics which are individually addressed in the introductory

[9] Constructing indicators which solely on code words is questionable, because there are tendencies within the ECB to abandon the usage of specific code words (see e.g. an interview with Dr. Axel Weber, president of the Bundesbank and member of the ECB governing council, published in the Financial Times Europe, 28. May 2007).

[10] Mediatenor has a strong experience in coding articles of media releases and capturing their content. Their analysts achieve a high rate of correlation which means that doing this exercise twice should lead to almost the same outcome. Furthermore, the employees are well trained in semantic coding but are not professional economists.

[11] For instance we capture the main theme, the judgment assessed to it, the directional change, the time horizon, etc.

Figure 3.7: ECB Communication and Interest Rates



Solid line, left scale: ECB key refinancing rate; dashed line, right scale: communication indicator on future price developments.

statement. For each of those sectors we calculate the share of statements addressing expectations by the central bank concerning rising values relative to falling values. For prices we use statements dealing with the consumer price index, prices in general, wages, and oil price developments. For the real economy we employ statements on GDP development, for exchange rates and monetary growth we just included statements on these specific topics. Furthermore, as a statement in time t has to been seen in relation to previous statements – that is $t - i$ – we aggregate over the past shares. Figure 3.7 depicts the index on future price developments together with the main refinancing rate of the ECB. The graph clearly shows that our index leads the interest rate cycle. Calculating the cross-correlations reveals that the highest correlation is reached at a 3-months lagged difference. This finding is perfectly in line with the observed ECB monetary policy. The ECB prepares markets for possible actions well in advance.

3.3.5 A Closer Look at the Data

Table 3.1 visualizes the movement in the absolute five-minute returns during the time span of interest (13.40–15.30) for all control days, all announcement days, announcement days with no (median) surprise and announcement days with (median) surprise.[12] The three largest volatilities in each column are marked by three, two and one stars respectively where three stars signify the largest volatility. The largest volatility in each row is marked as a bold number. Due to the U.S. announcements at 14.30, the control days reveal a single peak in volatility at 14.35. At 14.40 volatility immediately falls back to its previous level. The announcement days are characterized by three volatility peaks. The first and largest one due to the ECB press release at 13.45, the second one (as with the control days) at 14.35 and the third one due to the introductory statement at 14.45. Since the introductory statements start with a general assessment followed by comments on prices, the real economy and monetary aggregates, it is reasonable that the volatility becomes more pronounced somewhere in the mid-end of the statement. The announcement days with no surprise have two major volatility peaks. A first one again induced by the U.S. announcements, and a second one clearly due to the ECB introductory statement, i.e. on announcement days with no surprise the attention of the market participants shifts from the press release to the press conference. Finally, announcement days with surprise are dominated by the huge increase in volatility right after the press release. If we concentrate on the highest volatility across samples, at each point in time the surprise sample dominates all other samples' movements with only two exceptions over the whole time span. Especially at the announcement time of the interest rate decision the absolute return is nearly six times larger than in our control sample. Even compared to the non-surprise announcement days it is five times larger.

Overall, this eyeballing exercise suggests that both the press release and the press conference have a strong impact on the volatility of the EUR-$ exchange rate on ECB announcement days. Moreover, there is clear evidence for the outstanding role of interest surprises in comparison to usual announcement days.

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[12] Here we use median surprises because they occur less frequent than mean surprises and hence allow for a 'strong' separation of our sample in surprise and no surprise days.

Table 3.1: Mean Absolute Value of Five-Minute EUR-$ Returns.

	CD	AD	NS	SD
13.40	0.024	0.022	0.022	**0.025**
13.45	0.023	0.035	0.032	**0.056**
13.50	0.028	0.062***	0.043	**0.213*****
13.55	0.027	0.038	0.035	**0.063**
14.00	0.025	0.041	0.035	**0.085***
14.05	0.028	0.038	0.036	**0.059**
14.10	0.027	0.036	0.033	**0.054**
14.15	0.026	0.036	0.030	**0.086****
14.20	0.028	0.035	0.032	**0.061**
14.25	0.026	0.032	0.029	**0.055**
14.30	0.037*	0.043	0.043	**0.046**
14.35	0.051***	0.050**	0.049***	**0.056**
14.40	0.039**	0.044	0.044	**0.045**
14.45	0.035	0.049*	0.048**	**0.056**
14.50	0.036	0.046	0.046*	**0.053**
14.55	0.033	0.043	0.040	**0.066**
15.00	0.034	0.037	0.034	**0.061**
15.05	0.032	**0.035**	**0.035**	0.032
15.10	0.030	0.030	0.028	**0.047**
15.15	0.031	0.036	0.035	**0.041**
15.20	0.030	0.031	0.030	**0.039**
15.25	0.028	**0.030**	**0.030**	0.028
15.30	0.029	0.036	0.036	**0.039**

CD: Control Days, AD: Announcement Days, NS: No median Surprise days, SD: median Surprise Days. The three largest volatilities in each column (over the time period) are marked by three, two and one stars respectively. The largest volatility in each row (at each point in time) is marked as a bold number.

3.4 The FIGARCH Model

The decay behavior of the autocorrelation function of the absolute filtered return series investigated in Section 3.3.2 suggests that the conditional variance of the filtered return series should be modeled as a fractionally integrated process. Among the GARCH-type models which allow for such a behavior in the conditional variance, the Fractionally Integrated GARCH (FIGARCH) model

proposed by Baillie et al. (1996) is definitely the most prominent one. The FIGARCH model has been successfully applied e.g. by Baillie et al. (2000) to analyze the high-frequency Deutschmark-$ exchange rate and by Beine et al. (2002) to investigate the effects of central bank interventions on the volatility of the Deutschmark-$ and Japanese Yen-$ exchange rate.

The econometric model we apply to the filtered return series is autoregressive in the mean and obeys residuals which follow a FIGARCH process. In both equations – the conditional mean and variance – we allow for explanatory variables, namely the surprise measures, the communication indicators, controls for the Q&A session and interaction terms. For the mean equation we assume the following autoregressive structure for the filtered returns $\widetilde{R}_{k,n}$ including I_1 exogenous regressors $X_{k,n,i}$.

$$\widetilde{R}_{k,n} = \mu + \sum_{j=1}^{P} \varphi_j \widetilde{R}_{k,n-j} + \sum_{i=1}^{I_1} \delta_i X_{k,n,i} + \varepsilon_{k,n} \tag{3.4}$$

The innovations $\{\varepsilon_{k,n}\}$ follow a FIGARCH(p, d, q) process defined via the equations

$$\varepsilon_{k,n} = Z_{k,n}\sqrt{h_{k,n}}$$

where $\{Z_{k,n}\}$ is a sequence of $i.i.d.$ random variables with $\mathbf{E}(Z_{k,n}) = \mathbf{E}(Z_{k,n}^2 - 1) = 0$, and

$$(1-L)^d \Phi(L)\varepsilon_{k,n}^2 = \omega + B(L)v_{k,n}, \tag{3.5}$$

for some $\omega \in \mathbb{R}^+$, with $v_{k,n} = \varepsilon_{k,n}^2 - h_{k,n}$, lag polynomials $\Phi(L) = 1 - \sum_{i=1}^{q} \phi_i L^i$, $B(L) = 1 - \sum_{i=1}^{p} \beta_i L^i$, and $0 \leq d \leq 1$ being the fractional differencing parameter. The FIGARCH model reduces to the GARCH model for $d = 0$ and to the IGARCH model for $d = 1$. For any $0 < d < 1$ the FIGARCH process is not covariance stationary, since its unconditional variance does not exist. The question whether the model is strictly stationary or not is still open at present. For an in depth discussion of the properties of the FIGARCH model see Conrad and Haag (2006). An important issue in specifying a valid FIGARCH model is to restrict the parameters of the process such that the conditional variance $h_{k,n}$ is non-negative almost surely for all k and n. Necessary and sufficient conditions have been derived in Conrad and Haag (2006). These conditions ensure that all the ψ_i

coefficients in the so-called ARCH(∞) representation of the FIGARCH process are non-negative. The FIGARCH implies the ARCH(∞) representation

$$h_t = \frac{\omega}{B(1)} + \left(1 - \frac{(1-L)^d \Phi(L)}{B(L)}\right) \varepsilon_t^2 = \frac{\omega}{B(1)} + \sum_{j=1}^{\infty} \psi_j \varepsilon_{t-j}^2, \tag{3.6}$$

where, for simplicity, we changed the notation for the subindex from k, n to $t = 1, \ldots, KN$. Since the FIGARCH$(1, d, 1)$ will be used in the next section, we restate the necessary and sufficient condition for this model explicitly. First, note that for the $(1, d, 1)$ model the ARCH(∞) coefficients can be derived recursively as $\psi_1 = d + \phi_1 - \beta_1$ and $\psi_j = \beta \psi_{j-1} + (f_j - \phi_1)(-g_{j-1})$ for $j \geq 2$, where $f_j = (j - 1 - d)/j$ and $g_j = f_j \cdot g_{j-1}$ with $g_0 = 1$. The necessary and sufficient conditions are then given by (see Conrad and Haag, 2006, Corollary 1): case (i) $0 < \beta_1 < 1$, either $\psi_1 \geq 0$ and $\phi_1 \leq f_2$ or $\psi_{j-1} \geq 0$ and $f_{j-1} < \phi_1 \leq f_j$ with $j > 2$; case (ii) $-1 < \beta_1 < 0$, either $\psi_1 \geq 0$, $\psi_2 \geq 0$ and $\phi_1 \leq f_2(\beta_1 + f_3)/(\beta_1 + f_2)$ or $\psi_{j-1} \geq 0$, $\psi_{j-2} \geq 0$ and $f_{j-2}(\beta_1 + f_{j-1})/(\beta_1 + f_{j-2}) < \phi_1 \leq f_{j-1}(\beta_1 + f_j)/(\beta_1 + f_{j-1})$ with $j > 3$.

Bollerslev and Mikkelsen (1996) provided a sufficient condition for the non-negativity of the conditional variance, which is overly restrictive in comparison to the necessary and sufficient set. In particular, their condition implies the upper bound $\phi_1 < f_3$, which is often violated for high-frequency data (see Baillie et al., 2004).

Alternatively, we allow for I_2 exogenous regressors in the conditional variance equation.

$$B(L) h_{k,n} = \omega + \sum_{i=1}^{I_2} \omega_i X_{k,n,i} + \left(B(L) - (1-L)^d \Phi(L)\right) \varepsilon_{k,n}^2 \tag{3.7}$$

In equation (3.7) all exogenous variables $X_{k,n,i}$ are chosen such that they are known at time $k, n-1$ with certainty. In this way, we ensure that $\mathbf{E}(\varepsilon_{k,n}^2 | \mathcal{F}_{k,n-1}) = h_{k,n}$ is a constant and can be interpreted as a conditional variance. E.g. the conditional variance at 13.50 will be explained by the surprise realized at 13.45, i.e. we explain $h_{k,13.50}$ by choosing $X_{k,n,i}$ as $sr_{k,13.45}^{+}$ and $|sr_{k,13.45}^{-}|$.

3.5 Empirical Results

3.5.1 Pure AR-FIGARCH Models

Before we analyze the effects of the monetary policy decisions on the level and volatility of the EUR-$ exchange rate in detail, we present in Table 3.2 estimation results from pure AR-FIGARCH models for the control sample and the announcement days without including any exogenous regressors.[13] The serial correlation in the filtered five-minute return series is well captured by the inclusion of three autoregressive lags in the mean equation, while in the conditional variance a FIGARCH$(1, d, 1)$ was the preferred specification based on the Akaike and Schwartz information criteria compared to models of higher order. To capture the apparent leptokurtosis in the filtered return series, the innovation term is assumed to be t-distributed with ν degrees of freedom. As can be seen from Table 3.2, the constant and the estimated AR parameters in the mean equation are highly significant. The estimated persistence parameter, $\widehat{d}$, in the conditional variance equation is around 0.3 and significantly different from zero or one. The $\widehat{\phi}_1$ and $\widehat{\beta}_1$ parameters are again highly significant and lie inside the necessary and sufficient parameter set provided by Conrad and Haag (2006).[14] Moreover, the Ljung-Box Q-statistics for the squared standardized residuals (not reported) indicate that the FIGARCH specification does very well in capturing the hyperbolic memory in the squared filtered returns. Most importantly, the parameters estimated for the control days and the announcement days are very similar and, with the exception of $\widehat{\phi}_1$, not statistically different from each other.[15] Thus, we conclude that the same underlying process is apparent in both samples.

Next, we reestimate the AR(3)-FIGARCH$(1, d, 1)$ models with dummy variables in the conditional mean and variance equation at 13.50, 14.35 and 14.45.[16] As expected, for the control days none of the dummies is significant, indicating that the filtered control day returns are free of any effects due to macroeconomic announcements. The picture for the announcement days is very

[13] For reasons of comparability, we use a control sample which consists of 89 days, the same number of days that we have for ECB announcement days. The control days were chosen randomly as the Thursday either one week before are one week after the announcement day.

[14] Note, that they lie outside the sufficient parameter set given by the Bollerslev and Mikkelsen (1996). In particular, $\widehat{\phi}_1 > \widehat{f}_3$, the case typically observed for high-frequency data.

[15] The lower first order autoregressive coefficient estimated for the announcement days sample is presumably due to the news which effect the market on those days and drive the exchange rate into a direction unforecastable by the autoregressive specification.

[16] We omit the parameter estimates for reasons of brevity.

Table 3.2: AR(3)-FIGARCH(1, d, 1) Models for Filtered EUR-$ Returns.

	μ	φ_1	φ_2	φ_3	$\omega \cdot 10^{-4}$	ϕ_1	β_1	d	ν
CD	0.0009**	0.1234***	-0.0653***	-0.0239***	1.3899***	0.7271***	0.8241***	0.2976***	5.5060***
	(0.0004)	(0.0072)	(0.0065)	(0.0063)	(0.2019)	(0.0300)	(0.0221)	(0.0176)	(0.1865)
AD	0.0008**	0.0941***	-0.0557***	-0.0288***	1.3413***	0.7083***	0.8032***	0.3103***	5.4455***
	(0.0003)	(0.0070)	(0.0062)	(0.0059)	(0.1986)	(0.0315)	(0.0236)	(0.0201)	(0.1824)

Robust standard errors are given in parenthesis. CD: Control Days. AD: Announcement Days.

different. While we find no significant effects in the mean, the dummies in the variance are highly significant at 13.50 and 14.45, but not at 14.35. This outcome is convincing. First, only surprise news (which are not adequately captured by a simple dummy variable) should have an effect on the exchange rate return, while as reported in Andersen et al. (2003) the volatility obeys a pure announcement effect. Second, the effects due to the U.S. announcements which were clearly visible in Table 3.1 are no longer evident in the filtered series. Finally, we controlled for the possibility that news may leak into the markets before the official release date. However, any additional dummy variable before the press release at 13.45 turned out to be insignificant.[17]

3.5.2 The Explanatory Power of Surprises and Communication

In the following section we use the Reuters surprise data and the communication indicators to investigate whether the movements in the mean and variance can be explained by the size and sign of those variables. Tables 3.3 and 3.4 present our main estimation results. For utmost transparency the results are structured in the following way. First, in the spirit of Almeida et al. (1998) and Kearns and Manners (2006), we aggregate the response to the press release over different time intervals. Thus we can compare the magnitude and the direction of the response at a 5, 20 and 30 minute interval. This allows us to judge whether there is an immediate response, whether the response is building up or whether there is a backlash. Second, we aggregate the returns surrounding the introductory statement over the period 14.35-14.50.[18] This is necessary since statements e.g. about future inflation are made at different points in time during the various introductory statements. By doing so, we capture the overall impact of the introductory statement. For the sake of brevity we do not report the structural AR-FIGARCH parameters which were found to be very similar to the ones presented in Table 3.2.

After a preliminary analysis, we decided to separate the surprise measure into positive and negative surprises in order to control for asymmetries. There are good reasons to believe that for instance good news lead to different responses relative to bad news. E.g. Andersen et al. (2003) as well as Ehrmann and Fratzscher (2005b) provide evidence for asymmetric responses. With respect

[17] Ehrmann and Fratzscher (2005b) argue that news may leak into the markets before the official release date. This argument has low applicability for central banks. For instance central bank officials are not allowed to speak one week ahead of the official press release about the upcoming decision meeting. Hence, there is low probability that this information comes into the market shortly before the official meeting.

[18] The return form 14.30 to 14.35 is excluded from the aggregation scheme, because it may be contaminated by reactions to the U.S. announcements which take place at 14.30.

to the communication instrument we include forward-looking communication on exchange rates, inflation, the real economy and monetary aggregates. Notably only news on exchange rates and inflation significantly drive exchange rates. All other communication did neither impact the mean nor the variance equation.[19] For space considerations we omitted the parameter estimates of those variables from the tables presented below. The results make intuitively sense since (i) exchange rates should directly be affected by an assessment of the central bank and (ii) news on future price movements should be naturally the most important message as it is the ECB's primary objective to achieve price stability. In addition, we also controlled for a possible impact of the Q&A session by employing dummy variables for the period 14.50-15.15 in the estimation setup. Those were, however, not significant.

Turning now to the estimation results, a very stable and compelling picture emerges. Table 3.3 presents the coefficient estimates for the three different aggregation schemes denoted by (1)–(3). E.g. in aggregation scheme (2) the five-minute returns for the periods 13.45-14.05 and 14.35-14.50 are replaced by the aggregate returns $\widetilde{R}_{k,13.45-14.05}$ and $\widetilde{R}_{k,14.35-14.50}$. As can be seen from Table 3.3, an unexpected increase of the interest rate has an immediate positive and significant impact on the exchange rate. The positive effect is increasing within the first twenty-minutes and then comes back to the size of the initial reaction after thirty-minutes. Hence, a positive surprise leads to a prolonged appreciation of the EUR-$ exchange rate. This can be explained by market participants who expect further rising interest rate returns and a booming economy. Another line of argumentation would be that market participants try to predict the interest step assuming that the ECB follows some type of Taylor-rule. If they observe that the countermeasures taken by the ECB to fight inflationary pressure are more hawkish than expected, that is if the interest step taken implies that the inflation aversion parameter of the Taylor-rule function has to be adjusted upward, the logical consequence is to demand more currency. Looking at the effect of a positive surprise on the volatility, we find evidence for a cumulative volatility response which is gradual and seems to build up during the thirty-minute interval, an observation also made by Andersen et al. (2003).[20] The negative surprise is significant at the twenty-minute interval only, i.e. it seems to require some time to evoke a significant market reaction which then vanishes again at the horizon of half an hour. At the twenty-minute interval a negative surprise implies a depreciation of the home currency which

[19] In line with Chapter 2, Ehrmann and Fratzscher (2007b) report that during the press conference especially statements on inflation had the "largest and most systematic" impact on the 3-month Euribor futures rates.

[20] This does not mean that the level of volatility is constantly increasing during the thirty-minutes after the press release. The main increase in volatility occurs directly after the press release and is then followed by a period of "more than usual" volatility.

Table 3.3: The Impact of Surprises and Communication on the Filtered EUR-$ Returns (01/99 - 10/06).

	(1)		(2)		(3)	
	$\widetilde{R}_{k,13.45-13.50}$	$\widetilde{R}_{k,14.35-14.50}$	$\widetilde{R}_{k,13.45-14.05}$	$\widetilde{R}_{k,14.35-14.50}$	$\widetilde{R}_{k,13.45-14.15}$	$\widetilde{R}_{k,14.35-14.50}$
	Mean Equation					
$sr^{+}_{k,13.45}$	0.7294*		1.8330***		0.7346**	
	(0.4351)		(0.4466)		(0.394)	
$\lvert sr^{-}_{k,13.45}\rvert$	-0.0992		-0.9340***		-0.4439	
	(0.6460)		(0.3257)		(0.4918)	
$CE_{k,14.35-14.50}$		0.1490***		0.1411***		0.1463***
		(0.0368)		(0.0386)		(0.0381)
$CI_{k,14.35-14.50}$		0.0108***		0.0103**		0.0102***
		(0.0042)		(0.0040)		(0.0037)
	Variance Equation					
$sr^{+}_{k,13.45}$	0.1685*		0.5488*		0.7401**	
	(0.0867)		(0.2983)		(0.3270)	
$\lvert sr^{-}_{k,13.45}\rvert$	0.2034		0.4980***		0.2185	
	(0.1267)		(0.2329)		(0.3400)	
$\lvert CE_{k,14.35-14.50}\rvert$		0.0036		0.0034		0.0038
		(0.0031)		(0.0028)		(0.0027)
$\lvert CI_{k,14.35-14.50}\rvert$		0.0063***		0.0062***		0.0062***
		(0.0024)		(0.0023)		(0.0023)

Notes: *, ** and *** denote significance at the 10%, 5% and 1% level. Robust standard errors are given in parenthesis. $sr^{+}_{k,13.45}$ measures positive surprises, while $\lvert sr^{-}_{k,13.45}\rvert$ is the absolute value of negative surprises. $CE_{k,14.35-14.50}$ and $CI_{k,14.35-14.50}$ are the communication indicators with respect to the future development of the exchange rate and prices.

is in line with the impact of the positive surprise. As we will see in the upcoming section, it seems sensible to control for the type of the surprise which raises the relevance of a negative interest rate surprise. The effect of negative interest rate surprises on the level of volatility is similar to the one of positive surprises. However, the cumulative volatility response reaches its maximum at twenty-minutes already. To sum up, the asymmetry in the reported results justifies our estimation setup.

Concerning our communication indicators, the ECB's statements assessing the future exchange rate development ($CE_{k,14.35-14.50}$) are of great importance. Interestingly, the estimated coefficient is very stable independent of the time aggregation surrounding the press release. Because the coefficient has a positive sign, it indicates that the ECB has the credibility to talk up the exchange rate. Notably, there is no significant effect on the variance. This result is quite remarkable since it suggests that the ECB is able to steer the exchange rate without disturbing the markets or causing inefficient variation in the exchange rate. A similar result is found in Siklos and Bohl (2006) who report that ECB statements that focus on the outlook for the EUR-$ exchange rate lead to a diminution of exchange rate volatility and hence they argue that "statements can be constructed as being informative in the sense that these reduce the risks surrounding exchange rate developments".

With respect to news about the future inflation rate ($CI_{k,14.35-14.50}$) we find evidence for a positive relationship. As argued in Section 3.2, this result suggests that market participants use the new information about future inflation rates to update their beliefs about the ECB's future interest rate setting. This result is also in line with the predictions of Clarida and Waldman (2007). They argue that a positive inflation surprise together with a Taylor-type monetary policy rule leads to an appreciation of the exchange rate.

In order to obtain a deeper understanding for the communication indicator we are most interested in, namely the one on future inflation developments, we reestimate our models after dividing the sample into two sub-periods using May 2003 as the breakpoint. At this date the ECB changed the structure of the introductory statement, highlighting the importance of non-monetary issues.[21] The results presented in Table 3.4 provide strong support for the hypothesis that communication on future price developments gained importance over time.[22] While in the period 01/99–04/03 the coefficient estimate for the communication on the future inflation rate is negative, tiny and insignif-

[21] For a discussion on this potential breakpoint see also Berger et al. (2006a).

[22] The results presented in Table 3.4 are robust to the different aggregation schemes surrounding the time of the press release.

Table 3.4: The Impact of Communication: Structural Stability.

	Mean Equation		Variance Equation	
	01/99 - 04/03	05/03 - 10/06	01/99 - 04/03	05/03 - 10/06
$CI_{k,14.35-14.50}$	-0.0079	0.0150***	0.0061	0.0057**
	(0.0088)	(0.0045)	(0.0055)	(0.0022)

Notes: *, ** and *** denote significance at the 10%, 5% and 1% level. Robust standard errors are given in parenthesis. Returns surrounding the press release were aggregated for the period 13.45-14.05, returns surrounding the introductory statement for the period 14.35-14.50.

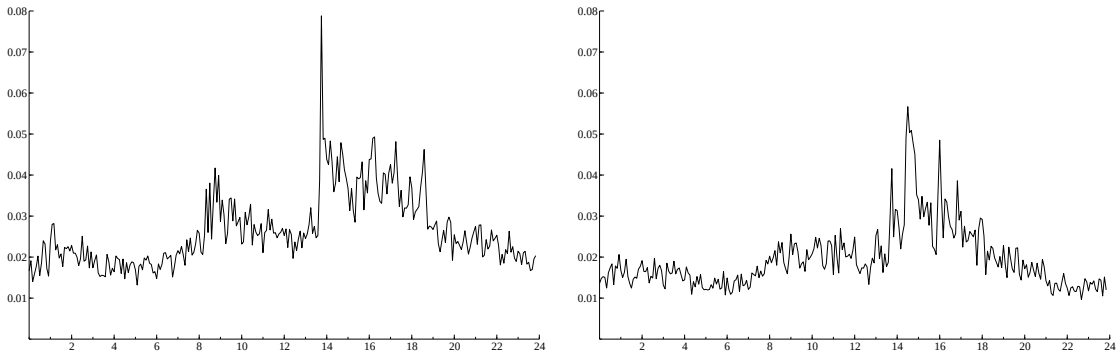
icant, it turns out to be positive and significant in the period 05/03–10/06. Also the variance of the EUR-$ exchange rate is significantly effected by communication on the future inflation rate in the second subperiod. According to Ehrmann and Fratzscher (2007a) central banks can influence asset prices by their communication only if they possess credibility and a strong track record to do so. In the light of the above results, the ECB considerably gained credibility during the last years, making its communication a more and more powerful tool with which it can influence the exchange rate.[23] The introductory statement reveals important information about how the central bankers assess the future outlook, in particular with regards to inflation. Thus, the introductory statement serves as an important channel through which valuable information about the future policy path is provided to the market participants.

Figure 3.8 supplements the above findings concerning the rising importance of ECB communication by a simple graphical illustration. For all announcement days, the figure shows a striking difference in the intraday volatility pattern of the EUR-$ exchange rate between the subperiods 01/99–04/03 and 05/03–10/06. While in 01/99–04/03 the press release dominates the whole day, it looses much of its importance in 05/03–10/06. In sharp contrast, in this second period the press conference has become most important.[24] Hence, we observe two developments: first, interest rate surprises become smaller and, second, communication becomes more important. Whether the first development is due to the fact that the ECB recently better prepared its interest rate deci-

[23] Notably this is not an exclusive explanation. One could also argue that the public learned to better understand the ECB over time or that the ECB is now able to communicate in greater clarity than it did at the beginning.

[24] A similar pattern emerges when we focus on announcement days with no surprise only. For those days the press conference and the press release are of equal importance in the first subsample, while the press conference is clearly more important in the second subsample.

Figure 3.8: Average Absolute Five-Minute EUR-$ Returns for each Five Minute Interval



The left panel shows announcement days before May 2003. The right panel depicts announcement days from May 2003 onwards.

sions or whether market participants learned better to forecast the decision can not be decided on the basis of our analysis. However, it should be undoubted that market participants increased the weight they attach to the introductory statement.

In summary, our results are very much in line with Almeida et al. (1998, p. 396) who argue that "... the exchange rate behaves according to a model where international capital flows dominate trade flows, i.e. the key variable for exchange rate determination is the interest rate differential and where the monetary authorities set interest rates according to their expectations of future inflation."

3.5.3 Further Evidence

This section will we elaborate on the stability of our results and gain some additional insights while conditioning on several circumstances. In Table 3.5 we interact our surprise measure controlling for positive and negative interest rate changes. To put it differently, we analyze the possibility that the effect of interest rate surprises depends on the direction of the interest rate change. For example, a positive surprise might on the one hand result from a stronger monetary policy tightening than expected but on the other hand might represent a situation in which the forecasters expected a significant loosening while the outcome was just a marginal lower interest rate. Controlling for these possibilities we indeed find significant differences. While a positive surprise driven by an increase in the interest rate triggers an appreciation of the exchange rate, a positive surprise in combination with a falling interest rate has no significant effect. While the first result is in line with

the outcome reported in Table 3.3, the second result is a bit surprising. However, the second result is mainly driven by the interest rate change on October 11th, 2001. After the terror attacks of 09/11 the ECB reduced the interest rate by 50 basis points, whereas market participants expected an even stronger monetary loosening. Thus, our negative and insignificant coefficient can be explained by the fact that the market participants did not consider the action taken by the ECB to stabilize the economy as being sufficiently strong.

With regards to the two types of negative surprises, both are associated with a depreciation of the home currency. They are, however, significantly different from each other. A negative surprise associated with a rising interest rate has a much stronger impact than a negative surprise of the same size associated with a declining interest rate. That is, if market participants overestimate a monetary tightening they adjust much stronger than if they would have underestimated a loosening. A likely explanation for this phenomenon might be that individuals fear inflationary pressure more than deflationary tendencies. In line with Andersen et al. (2003) this finding can also be interpreted as evidence for the claim that bad news in good times cause stronger reactions than bad news in bad times. This is, because negative interest rate surprises in combination with positive interest rate changes are likely to appear in a booming economy which might have reached its turning point. Negative interest rate surprises in combination with negative interest rate changes usually occur during recessions. Overall, it becomes clear that focussing on the characteristics of positive and negative surprises has more to tell than assumed so far.[25]

Obviously, this detailed view might have implications for the way the communication is conducted and how it is perceived by the public. Those implications are captured by Table 3.6 where we interact our communication indicator, $CI_{k,14.35-14.50}$, with several dummy variables controlling for the sign of the previous interest rate change and surprise. First, we observe that the variables which measure communication with respect to inflation and the EUR-$ exchange rate remain reasonably stable independent of the control variables we added. This is certainly an outcome that underlines the coherence of our results with respect to the role that communication plays.

With Model (1) we check whether communication is perceived differently when inflation is high (above 2.2) or low (below 1.5) percent. The results reveal that the impact of communication does not vary with inflation lying outside the upper target of the ECB. However, if inflation is below 1.5, then the net effect of news about raising future inflation is no longer significantly different from

[25]However, it should be noted, that the coefficient estimates for the cases $sr^{+}_{k,13.45} \times \mathbf{1}_{\Delta r_{k,13.45}<0}$ and $|sr^{-}_{k,13.45}| \times \mathbf{1}_{\Delta r_{k,13.45}>0}$ are based on a few observations only.

Table 3.5: Interactions Surprises.

$sr^{+}_{k,13.45} \times \mathbf{1}_{\Delta r_{k,13.45}>0}$	$sr^{+}_{k,13.45} \times \mathbf{1}_{\Delta r_{k,13.45}<0}$	$\lvert sr^{-}_{k,13.45}\rvert \times \mathbf{1}_{\Delta r_{k,13.45}>0}$	$\lvert sr^{-}_{k,13.45}\rvert \times \mathbf{1}_{\Delta r_{k,13.45}<0}$
Mean Equation			
0.6914**	-0.0309	-24.6121***	-0.8524***
(0.2951)	(3.8514)	(1.6322)	(0.3157)

Notes: *, ** and *** denote significance at the 10%, 5% and 1% level. Robust standard errors are given in parenthesis. $\mathbf{1}_{\Delta r_{k,13.45}>0}$ defines an indicator which is one if there was positive interest rate change. $\mathbf{1}_{\Delta r_{k,13.45}<0}$ is defined analogously. Returns surrounding the press release were aggregated for the period 13.45-14.05, returns surrounding the introductory statement for the period 14.35-14.50.

zero. The reason behind this might be that in such a situation market participants do not expect the ECB to increase the interest rate since inflation is moving towards its target level.

Turning to Models (2), (3) and (4) it becomes obvious that communication is most relevant in connection with negative interest rate changes as well as negative surprises. Not surprisingly, the negative surprise variable has a stronger impact than the negative interest rate change, since the latter contains also an expected component. If there is a monetary loosening and the ECB notes that the inflation is going down ($CI_{k,14.35-14.50} \times \mathbf{1}_{\Delta r_{k,13.45}<0}$) this implies a further appreciation of the exchange rate, because market participants would expect that the engagement of the ECB to fight inflation paid off. Moreover, if the public views that the positive interest change is lower than expected (negative surprise) and the communication indicates a rise in future inflation ($CI_{k,14.35-14.50} \times \mathbf{1}_{sr^-_{k,13.45}} \times \mathbf{1}_{\Delta r_{k,13.45}>0}$) this is very bad news for the public and leads to a strong depreciation. In this case people fear that the action taken by the ECB may not be sufficient to fight inflation. If in such a scenario the ECB raises concerns about rising future inflation this amplifies the message and leads to a further depreciation of the home currency. If there is a positive surprise going along with a falling interest rate and the ECB communicates an expected rise in the future inflation ($CI_{k,14.35-14.50} \times \mathbf{1}_{sr^+_{k,13.45}} \times \mathbf{1}_{\Delta r_{k,13.45}<0}$), this might indicate a turnaround and may be interpreted as rising future interest rates which in turn lead to an appreciation of the exchange rate. Note, that only interacting a positive surprise with a positive change had no significant effect. However, in such a constellation the EUR-$ exchange rate appreciated already immediately after the press release and so ECB communication seems to add no additional news.

The results concerning the Q&A session which are reported as Model (5) are striking. The Q&A session itself does not have a significant effect. However, when we condition on the preceding interest rate decision as well as on the communication the Q&A session turns out to gain importance.[26] This result does not come by surprise as the Q&A is meant to complement the interest rate decision as well as the introductory statement. The following result emerges: if a negative surprise is complemented with an outlook of falling inflation ($\text{Q\&A}_{k,14.50-15.15} \times \mathbf{1}_{sr^-_{k,13.45}} \times \mathbf{1}_{\Delta CI^-_{k,14.35-14.50}}$) the Q&A serves as an instrument to compensate the shock of the press release and is followed by an appreciation.

To summarize, the overall effect of the press conference crucially depends on whether it was preceded by an interest rate surprise or not. If there was no surprise then the effect is mainly driven

[26] Here, we could only condition on two situations. This reason for this is that throughout our sample, positive (negative) interest rate surprises almost always occurred in connection with changes in our communication indicator of the same sign.

by the new information which shapes the markets expectations about future monetary policy. If there was a preceding surprise the effect is driven by the ECB's ability to explain its decision and hence can either strengthen or weaken the immediate response of the press release.

Finally, we would like to point out that our results deliver further support for a conjecture made in Andersen et al. (2003), namely that "news effects are in general a function of state uncertainty". E.g. we show that the effect of communication on the future inflation rate is very much dependent on whether this communication was preceded by an interest rate surprise or not. If market participants correctly anticipated the interest rate decision, their reaction mirrors that they feel certain about the state of the economy and the ECB's future monetary policy. On the other hand, if the decision lead to a surprise, this creates state uncertainty and the market participants reaction is driven by an adjustment process.

3.6 Conclusions

We analyze the effect of the ECB's monetary policy announcements on the level and volatility of the EUR-$ exchange rate. In particular, we disentangle the effects of an announcement day by focussing on the impact of the interest rate decision at 13.45, the introductory statement starting at 14.30 and the Q&A session following thereafter. The key result is that each of the three events significantly drives EUR-$ exchange rate movements at all three events. In detail, we find strong asymmetries in the response to the interest rate announcement, highlight the relevance of the ECB's assessment of the expected inflation path and exchange rate movements and provide evidence that all three instruments are interrelated and complement one another.

First, the impact of the interest rate announcement is significant if the decision was not anticipated by the market participants. Being more specific, an unexpected tightening of the monetary policy leads to an immediate appreciation of the EUR-$ exchange rate. The immediate reaction to an unexpected easing is weaker and the full response is partially delayed towards the press conference. Positive interest rate surprises induce prolonged increases in the volatility of the exchange rate, in contrast negative surprises have only weak effects.

Second, the introductory statement plays an important role for market participants. In particular, the forward-looking content is closely followed by market participants who try to predict the future policy path. In a fine grained analysis we provide evidence that the ECB's assessment of inflationary and exchange rate developments are outstanding for the response of the EUR-$ ex-

change rate. There is compelling evidence that a rise in the expected inflation rate mentioned in the introductory statement increases the value of the EUR. As our price indicator leads the interest rate cycle market participants might react to the expected rise of future market rates. This is in line with arguments put forward by Clarida and Waldman (2007). Thus, we provide evidence that information on price developments reveal more news to market participants than the ECB's assessment of developments in the monetary or real sector. Moreover, the index capturing news about expected movements of the exchange rate is relevant for market participants. Remarkably, while comments on the expected path of the exchange rate significantly impact exchange rate returns, they do not increase the volatility. We conclude that the ECB gained enough reputation to guide the public.

Third, while the previous paragraph highlighted the importance of the introductory statement because of its forward-looking character, we also find that the introductory statement has an important role in explaining unexpected interest rate decisions, in particular negative surprises. We provide remarkable evidence for interactions between communication and interest rate decisions. While, on average, communication has a positive coefficient estimate, this effect might be overruled if a surprise interest rate decision was announced beforehand. This is sensible because all three instruments are intended to complement each other and, consequently, must not be seen and estimated individually as it is the case in all the studies published so far. For instance, if there was a monetary tightening which was less strict than expected and if, in addition, the ECB states that inflationary pressure increases, this consequently leads to a depreciation.

Fourth, if there was a negative surprise and the ECB reported falling future inflation rates, we find a substantial movement during the Q&A session. The Q&A reinforces the statement. It seems that the Q&A session contains little news in itself but must be seen as a complement to the earlier assessment of the ECB. Finally, we explore the stability of our findings by splitting the sample period. We chose a breakpoint suggested by Berger et al. (2006a) which is motivated by a change in the structure of the introductory statement. The results indicate that there is growing relevance of the introductory statement. The communication indicator concerning price developments gains in significance and magnitude suggesting that communication has become a more and more powerful tool to guide expectations. We conclude that some learning process took place. The interrelationship between ECB decisions and the expectations of the market participants evolves and seems to stabilize over the recent years.

Table 3.6: Interactions Communication.

	(1)	(2)	(3)	(4)	(5)
	Mean Equation				
$CE_{k,14.35-14.50}$	0.1753***	0.1425***	0.1420***	0.1406***	0.1743***
	(0.0383)	(0.0386)	(0.0385)	(0.0386)	(0.0427)
$CI_{k,14.35-14.50}$	0.0353***	0.0118***	0.0115***	0.0110***	0.0327***
	(0.0110)	(0.0038)	(0.0040)	(0.0039)	(0.0094)
$Q\&A_{k,14.50-15.15}$					0.0008
					(0.0082)
$CI_{k,14.35-14.50} \times \mathbf{1}_{\pi_{k,13.45}>2.2}$	-0.0011				
	(0.0131)				
$CI_{k,14.35-14.50} \times \mathbf{1}_{\pi_{k,13.45}<1.5}$	-0.0422*				
	(0.0238)				
$CI_{k,14.35-14.50} \times \mathbf{1}_{\Delta r_{k,13.45}>0}$		0.0099			
		(0.0292)			
$CI_{k,14.35-14.50} \times \mathbf{1}_{\Delta r_{k,13.45}<0}$		-0.0421**			
		(0.0203)			
$CI_{k,14.35-14.50} \times \mathbf{1}_{sr^{+}_{k,13.45}}$			-0.2257		-0.1262
			(0.3064)		(0.3514)
$CI_{k,14.35-14.50} \times \mathbf{1}_{sr^{-}_{k,13.45}}$			-0.0923***		-0.0985***
			(0.0193)		(0.0082)
$CI_{k,14.35-14.50} \times \mathbf{1}_{sr^{+}_{k,13.45}} \times \mathbf{1}_{\Delta r_{k,13.45}>0}$				-0.4639	
				(0.3353)	

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	(1)	(2)	(3)	(4)	(5)
				Mean Equation	
$CI_{k,14.35-14.50} \times \mathbf{1}_{sr^{+}_{k,13.45}} \times \mathbf{1}_{\Delta r_{k,13.45}<0}$				0.1780***	
				(0.0219)	
$CI_{k,14.35-14.50} \times \mathbf{1}_{sr^{-}_{k,13.45}} \times \mathbf{1}_{\Delta r_{k,13.45}>0}$				-7.6822***	
				(0.1340)	
$CI_{k,14.35-14.50} \times \mathbf{1}_{sr^{-}_{k,13.45}} \times \mathbf{1}_{\Delta r_{k,13.45}<0}$				-0.0873***	
				(0.0181)	
$Q\&A_{k,14.50-15.15} \times \mathbf{1}_{sr^{+}_{k,13.45}} \times \mathbf{1}_{\Delta CI^{+}_{k,14.35-14.50}}$					0.0292
					(0.0398)
$Q\&A_{k,14.50-15.15} \times \mathbf{1}_{sr^{-}_{k,13.45}} \times \mathbf{1}_{\Delta CI^{-}_{k,14.35-14.50}}$					0.0866**
					(0.0367)

Notes: *, ** and *** denote significance at the 10%, 5% and 1% level. Robust standard errors are given in parenthesis. $\mathbf{1}_{\pi_{k,13.45}>2.2}$ is a dummy variable taking the value of one if inflation is above 2.2. The variable $\mathbf{1}_{\pi_{k,13.45}<1.5}$ is defined analogously. Similarly, $\mathbf{1}_{\Delta CI^{+}_{k,14.35-14.50}}$ and $\mathbf{1}_{\Delta CI^{-}_{k,14.35-14.50}}$ indicate whether there are positive/negative changes in the communication indicator with respect to inflation. Returns surrounding the press release were aggregated for the period 13.45-14.05, returns surrounding the introductory statement for the period 14.35-14.50.

CHAPTER 4

Signalling the Future Path of Monetary Policy: ECB Communication and the Media

4.1 Introduction

In this chapter we will further explore the relevance of central bank communication but without referring to market based instruments to proxy expectations. Market participants use the interest rate decision as well as the communication of the central bank to infer the future path of monetary policy. While the interest rate decision is an established instrument, as agents, for instance, estimate Taylor-type rules to forecast the next interest rate decision and the attitude of the central bank toward prices stability, the communication instrument attracted considerable attention over the last decades.[1] Researchers nowadays acknowledge the importance of central bank communication as a valid and important instrument to steer expectations and in turn to anchor price stability. Among the first Cukierman and Meltzer (1986) proposed that speeches and other forms of public communication by central bank officials, represent effective instruments that can influence inflation expectations. As communication is also relevant to establish transparency and credibility, and thus to improve policy making, there is a growing interest in this topic. Empirical research concentrates

[1] See for instance Sauer and Sturm (2007) on Taylor rules.

on the impact of communication on markets and market expectations. With respect to studies on interest rates behavior see for instance Lamla and Rupprecht (2006) and Heinemann and Ullrich (2007). Jansen and de Haan (2006) ask a distinct question by testing the explanatory power of ECB communication as an important tool to guide the public. Very recent studies like Ehrmann and Fratzscher (2007b) and Brand et al. (2006) explore the importance of the press conference relative to the announced interest rate decision for guiding the markets. They find that information provided by the press conference is more relevant than the content of the interest rate decision. They reach their conclusion observing market interest rates, e.g. 3 month Euribor futures. Analyzing the response of exchange rates Conrad and Lamla (2007) and Siklos and Bohl (2006) show that surprising interest rate decisions evoke stronger reactions than ECB communication. Being able to disentangle short-term policy reactions from long-term policy attitudes, Gurkaynak et al. (2005) contend that communication may be more effective in signalling the general monetary policy strategy, i.e. how "hawkish" a central bank is, while deeds indicate the short-term adjustments.

While in Chapters 2 and 3 we employed market instruments, this chapter draws conclusions on this issue using a different approach. The tools to measure the impact on or of expectations have been rather technically and indirectly by monitoring changes in market interest rates or exchange rates. Commonly, changes in future market instruments or changes in the slope of the yield curve have been utilized to track the impact of central bank actions and judge upon issues like transparency and credibility (see for instance Gurkaynak et al., 2000). Notably, from an economic theory perspective, those measures are sound ways to capture expectations. For example, if forward looking interest rates move after an announcement event, market participants must have adjusted their expectations due to the new information. However, as the market movements leave room for interpretations, are often short-lived and monitor just the view of an expert group, it seems sensible to look out for alternatives.

We lay out the path for a different approach to test for the relative importance of the press conference. Commonly the public infers how much weight the central bank places on price stabilization from the interest rate decision and from the communication. However, which of the two instruments is more important for guiding market expectations has not yet been analyzed thoroughly. Thus, we analyze the impact of the interest rate signal relative to the communication signal by capturing the expectations regarding the next interest rate step that emerged after the information that was spread and signalled on the meeting day. We infer the adjusted expectations of the public by surveying media releases printed one, respectively two days after the ECB's press conference. While markets may move quickly in one direction and after some time may turn back

and trend in the opposite direction, this method may pick up what was the bottom line. In the media echo, journalists write about how the interest rate decision of the ECB and the communication of the ECB has to be interpreted and what this implies for the expected next step. As accumulating and interpreting all information is costly, it is rational for the public to assimilate the judgment that is relevant for their expectations from a reliable and cheap source: the media.[2] This line of argumentation is also supported by Berger et al. (2006b). They investigate the determinants of the favorableness of ECB's actions as observed by the media and argue that media plays an important role in transmitting the ECB's policy intentions to their national audiences and thereby forming their expectations. Therefore, using articles dealing with the ECB meeting days appears to be a sound proxy for the future expectations of the public on the interest rate path. A great advantage of this approach is that we do not need to control for other macroeconomic factors as they should not change dramatically within this short time horizon and thus should already be digested and priced in. Due to the immediate response one, respectively two days later, we almost surely capture only the impact of the announcement of the monetary decision and the introductory statement on expectations. A second aspect that we want to tackle is the poor evidence with respect to the conditioning factors. For instance, we can investigate how important is central bank communication relative to the interest rate signal and is it stable over time? Furthermore, one could argue that the public follows the communication instrument more during times of low inflation or when market uncertainty is high. If inflation is not within the target range people should, if the announced targets are credible, be well aware that the central bank is likely to take action to ensure price stability in the medium-run. Thus, we test the impact of both signals conditioning on inflation rates, surprises, the interest rate cycle, and market uncertainty. Overall, we find that deeds do *not* necessarily matter more than words. On the one hand, it can be seen as the primary signal, on the other hand there are situations where communication is significantly more important, like for instance at the beginning of an interest rate cycle and when no action took place.

Our scope is to enlighten this discussion by providing empirical evidence using a completely different and novel approach. The analysis is structured in the following way. Section 4.2 describes the data used in this approach and places emphasis on the newly constructed indicators with respect to expectations as well as the communication indicator employed. Moreover, it describes the econometric methodology used. Section 4.3 presents the results while section 4.4 concludes.

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[2]See for instance Sims (2003). He argues that information processing is costly and thus agents are rationally inattentive.

Table 4.1: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	Observations
Expectations	-0.08	0.63	-1.00	1.00	65
Comm All	-0.01	1.00	-1.76	1.97	68
Comm Prices	-0.01	1.00	-1.91	2.04	68
Comm Money	0.00	0.99	-2.34	2.00	68
Comm Real	0.00	1.00	-1.64	2.02	68
interest rate ECB (i)	3.11	0.93	2.00	4.75	68
mean surp	0.01	0.09	-0.37	0.26	68
median surp	0.01	0.09	-0.25	0.25	68
Euro-area CPI	1.91	0.44	0.90	2.90	68

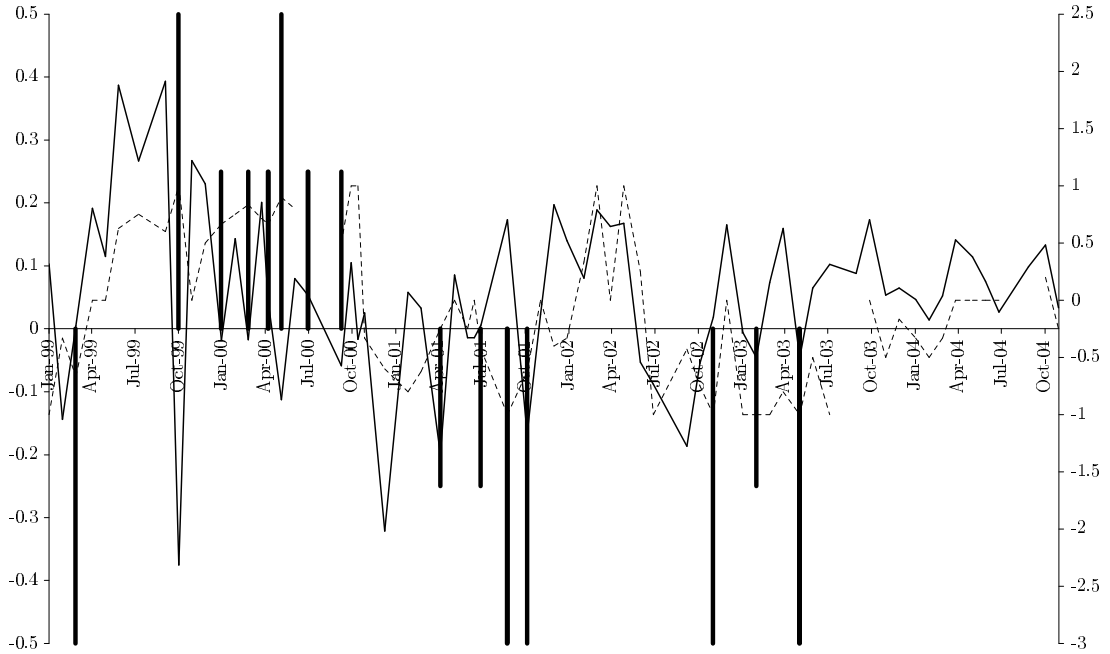
4.2 Data and Methodology

As noted earlier our approach requires data that captures the expectations of the public concerning the upcoming monetary policy decision of the ECB, data on interest rates as well as a variable proxying the content of the introductory statement. With respect to our expectations measure we rely on data kindly provided by Mediatenor, a media research institute. Mediatenor surveys and codes all articles dealing with the past interest rate decision and the policy relevant assessment of the ECB published one respectively two days after a central bank meeting. They read every article referring to the press conference and capture whether the author expects the ECB to perform a tightening or loosening policy in the future. The coding is based on articles extracted from the Financial Times Europe (FTE). FTE articles should guarantee a certain degree of expertise in interpreting and digesting the communication events accordingly. Moreover, the articles should reach a wider audience.[3] Our dependent variable is then calculated as the difference of the share of articles expecting an upcoming tightening monetary policy and those expecting a loosening monetary policy in the future. We name this variable "Expectations".

The communication indicator is taken from Berger et al. (2006a). It monitors the risk to price stability, e.g. a rising indicator means that the ECB's assessment of the economic situations implies a higher risk to price stability. This indicator can be disaggregated into three policy-relevant topics and is able to capture the risk to price stability stemming from the real sector, the monetary sector as well as developments in market prices. Notably, we are not able to monitor the impact of the question and answer session. As this is a platform to clarify the intentions of the preceding intro-

[3] Most likely similar articles could be expected to be published in other newspapers following similar standards.

Figure 4.1: Monetary Signals and Media Expectations



Bars are changes in the main refinancing rate of the ECB; dashed line represents the expectations concerning the next interest rate step; solid line denotes the ECB communication indicator.

ductory statement, but not to add additional information, it should not affect our interpretations and conclusions substantially.

Furthermore, we consider a set of variables that helps us to condition the signalling power. For this purpose we employ data measuring the surprise component of the interest rate decision, a proxy for state uncertainty and the inflation rate.

The surprise measures are taken from the Reuters survey of professional forecasters. One week ahead of the governing council meeting those financial market analysts are asked about the actions the ECB might take. The average respectively the median of the responses is then subtracted from the real interest rate decision taken by the ECB. A deviation from the professionals forecast should indeed be a surprise to the markets.

Euro-area CPI denotes the Euro average Harmonized Index of Consumer Prices as published by Eurostat. We create a dummy variable indicating whether the Euro area inflation overstepped the announced target rate and a second variable if inflation was within the band.

Market uncertainty is measured as the standard deviation of the 3 month ahead interest rate expectations as delivered by Consensus Economics. Consensus Economics collects the interest rate forecasts of several important banks, reports their estimates and calculates the mean and standard deviation. For our purpose we utilize the standard deviation as a proxy for state uncertainty. If the banks are not sure about the current state of the economy their expectations of the interest rate should be more disperse. Most likely if banks are not sure about the state of the economy the ECB as well as the public might be more uncertain, too.

To make the coefficients comparable and to be able to draw sensible conclusion we need to standardize the explanatory variables. We do this by normalizing each variable by subtracting its mean and dividing through its standard deviation.

Descriptive statistics are presented in Table 4.1. The change in the key refinancing rate, the ECB communication indicator as well as the expectation indicator are also depicted in Figure 4.1. The expectation indicator seems to lead the interest rate change. However, there are occasions, like October 1999, where misconceptions become evident as the indicator moves in the opposite direction.

For our analysis we employ the following setup.

$$E_t = \alpha + \beta \Delta c_t^{p_j} + \gamma \Delta c_t^i + \varepsilon_t \tag{4.1}$$

where E_t denotes our proxy for the public's expectations with respect to the next interest rate decision given the information set available today, c_t^i is the announced interest rate decision and $c_t^{p_j}$ with $j = a, p, m, r$ represents the communication of the central bank with respect to prices (p), monetary aggregates (m), the real sector (r) and an overall assessment (a) in the introductory statement. Note that t relates to the meeting day in each month. The media release comprising the response to the ECB announcement is captured up to two days later. We could estimate equation 4.1 using OLS with robust errors. However, as we are dealing with a dependent variable that is bounded between $[-1, 1]$, OLS might be inappropriate in this context. It has to be taken into account that if E_t is bounded the marginal effect of any particular explanatory variable cannot be constant throughout its range. Furthermore, the predicted values of the OLS regressions cannot

be guaranteed to lie in the unit interval. The problem becomes severe if a substantial mass of the distribution is located close to the bounds.

If the dependent variable $y \in (0,1)$ – which is a affine transformation to our case $y \in (-1,1)$ – one could simply model the log-odds ratio as

$$E\left(log\left[\frac{y}{(1-y)}\right]|X\right) = X\beta.$$

However, this is not an option as our variable takes on the values at the bounds $[-1,1]$. In order to bypass inference problems we follow Papke and Wooldridge (1996). First, we have to re-scale our variable to fit into the interval $[0,1]$ using the formula $\hat{y} = (y-\overline{y})/(\overline{y}-\underline{y})$ where $y \in [\underline{y}, \overline{y}]$. Then we estimate the equation using the Bernoulli log-likelihood function given by

$$l_i(b) = \hat{y}_i log[G(x_i b)] + (1-\hat{y}_i) log[1-G(x_i b)],$$

where $G(.)$ is the logistic function. β will be obtained by maximizing

$$\max_b \sum_{i=1}^{N} l_i(b).$$

The Bernoulli quasi-maximum likelihood estimator (QMLE) is a consistent and asymptotically normal estimator *regardless* of the distribution of y. To test for necessity of using the QMLE estimation method they propose the Ramsey RESET test.[4] Applying this test using OLS to the first regression using our communication indicator as well as the interest rate decision as explanatory variables the RESET test rejects the null hypothesis that the powers of the fitted dependent variable are insignificant at the 5% confidence level.[5] This implies that the model is misspecified and hence, applying this procedure is preferred.[6]

[4] See Ramsey (1969).

[5] F-test(3,58)=3.19; Prob>F=0.03

[6] Notably, comparing Table 4.2 with the results obtained from the ordinary least squares estimation, the qualitative implications are very similar. A reason for this may be that not much of the mass of the distribution of our dependent variable lies in the neighborhood of the bounds.

4.3 Results

We start off by analyzing the impact of the communication indicator and its different dimensions in conjunction with the interest rate movements. Table 4.2 depicts the results. As the series have been normalized with their standard deviation and their sample mean, we can directly compare the coefficient estimates.[7] Column (1) reveals that both instruments affect the expectations of the future interest rate path of the public. Moreover, we find that the interest rate decision has similar power to guide markets as the communication signal. The interest rate signal has a similar magnitude. In that respect deeds do not necessarily matter more than words. Monitoring and interpreting intraday movements in the EUR-$ exchange rate Ehrmann and Fratzscher (2007b) as well as Brand et al. (2006) find similar results. Columns (2), (3) and (4) investigate the relevance of the topic communicated. In line with very recent studies like Lamla and Rupprecht (2006) as well as Ehrmann and Fratzscher (2007b) we confirm that the ECB's assessment of price development matters most. Moreover, congruent with Berger et al. (2006a) we show that communication on the monetary aggregates is, relative to statements on prices, of minor importance. These observations seems reasonable as Romer and Romer (2000) provide evidence for the existence of an information advantage of the Federal Reserve with respect to developments in real output and inflation.[8] This type of asymmetric information is also likely to be present in the case of the ECB.

Columns (5) and (6) investigate whether the interest rate signal is mainly driven by market surprises or whether the observed interest rate change is more relevant. Indeed and contrary to the role that is often addressed with respect to surprises, we find that they have low coefficient estimates and seem to only marginally affect expectations. One explanation could be that surprises might increase the uncertainty of the future interest rate path and thus are associated with lower or insignificant coefficients while expected steps mainly reinforce ex-ante expectations. The relevance of the signals might also strongly depend on the economic situation. In a specific situation it might be easier to infer the expected path of the monetary policy of the ECB than in other states of the world. To analyze the stability of the estimated coefficients we condition on situations where inflation is above the target level or not, on the position within the interest rate cycle, on the type of the interest rate change and on market uncertainty.

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[7] Note, that the estimated coefficients are not the marginal effects. However, as we have normalized the variables beforehand we can directly compare the magnitude between the coefficient of the change in the interest rate and the change in the communication indicator.

[8] Romer and Romer (2000) simply compare the forecasting power of the Federal Reserves' own internal forecast with the publicly available forecasts and conclude that the Federal Reserves internal forecast clearly outperforms.

Table 4.2: Communication versus Interest Rate Signal

	(1)	(2)	(3)	(4)	(5)	(6)
Δi	1.052***	0.984***	1.008***	0.984***		
	(0.213)	(0.183)	(0.176)	(0.161)		
Δ Comm All	1.021***				0.707*	0.698*
	(0.338)				(0.406)	(0.415)
Δ Comm prices		0.623**				
		(0.274)				
Δ Comm money			0.254			
			(0.264)			
Δ Comm real				0.512		
				(0.317)		
MedianSurp					0.289	
					(0.203)	
MeanSurp						0.285*
						(0.171)
Constant	-0.272*	-0.233	-0.212	-0.213	-0.196	-0.194
	(0.157)	(0.153)	(0.156)	(0.154)	(0.154)	(0.157)
Obs.	64	64	64	64	64	64

Robust standard errors in parenthesis; ***/**/* denote the 1/5/10%-significance level

Table 4.3 summarizes the results. Columns (1), (2) and (3) check the response to the signals if inflation was close to but below 2%, which is the target level of inflation of the ECB. We can observe that communication is most relevant if inflation is within the target range as compared to a situation where inflation is above the level to achieve the goal of price stability. If inflation is above the limit it should be straightforward that the ECB will do what is necessary to bring down inflation. As this counterreaction is expected, journalists may attach less importance to further information provided in the introductory statement. On the other hand if inflation is within the band they listen carefully as the upcoming policy action is less obvious as in the latter scenario.

Column (4) investigates whether the position in the interest rate cycle is relevant. In a common Taylor-type reaction function some form of policy inertia is implemented. This implies that an adjustment usually takes place gradually, taking many small interest rate steps instead of one or few large steps. We create a count variable, counting interest rate steps within a cycle.[9] This

[9]Our sample consists of seven upwards adjustments and seven downward changes. Moreover, often 3 months lie between interest rate changes.

count variable is then interacted with the change in the interest rate as well as the change in the communication indicator. Only the interaction with the communication indicator seems to be relevant. The negative sign implies that with a certain progress in the adjustment to the new targeted interest rate level the communication becomes less important. After a bunch of interest rate changes in one direction the ECB made their intentions clear and people are likely to infer the new interest rate target. However, if there is a first rise, market participants might be unsure about the intensity and the length of the adjustment. A well in advance preparation of the ECB implies that if we are close to the end of an adjustment period people might be already adequately informed. Also, we control for specific types of interest rate changes. As shown in Chapter 3 there may be some inherent asymmetry in the response to interest rate changes.

Column (5) filters events where no interest rate change occurred. As the interest rate variable drops, people rely solely on the communication to infer the reasons for this, communication gains importance and the estimated coefficient value almost doubles. The option "no change" thus puts more weight on the communication. One could expect that "no change" happens in a phase of a gradual adjustment process (inertia) or in a time where the interest rate level is appropriate. In both scenarios people have a greater incentive to listen carefully in order to predict and prepare for the next adjustment in the interest rate. Column (6) investigates the response to positive relative to negative interest rate changes. First, we can observe that the communication coefficient increases dramatically. Second, we detect a significant asymmetry in the adjustment to an announced interest rate change. The response to a positive interest rate change is much more pronounced as compared to a negative interest rate change. This may be reasoned by the greater fear of inflationary tendencies compared to the risk of deflation. Especially, in financial markets it is not unusual that people react in an asymmetric way. For instance Andersen et al. (2003) conjecture that bad news in good times have a much higher impact that bad news in bad times.

The last column accounts for market uncertainty. Although the interaction terms are not statistically significant at conventional levels, we observe that the coefficients estimates with respect to a change in the interest rate as well as a change in the communication indicator increase substantially in their magnitude. Thus, if markets are stable and if uncertainty is modest, the signalling is more effective. This is a remarkable result. One could have also argued that the ECB should have incentives to guide markets in turbulent times. However, this appears to be not true.[10] One reason

[10]One has to be careful judging about the role of the ECB. As we do not observe any counterfactual we cannot evaluate if "not communicating" or "communicating differently" would be even worse. We just observe that the ECB is less effective in guiding expectations in times of great uncertainty.

for this may be that the ECB is reluctant to provide information about future interest rate steps as it itself cannot distill the future path of the economy much better than the market participants and wants its credibility not to put at risk. Misinterpreting developments and communicating them to the market, implies costs in form of loosing credibility.[11]

Finally, we are able to disentangle whether the media release in the Financial Times was authored by a journalist, by a staff member of the ECB or by other experts. Results are reported in Table 4.4. We observe that reports from ECB officials are in line with the signalling and the announced actions. This is no surprise as their communication in the newspaper should complement earlier decisions. Excluding statements from other experts as well as central bank officials our results are not affected which in turn reinforces our inference described so far.

To sum up, we find clear evidence that both, communication as well as interest rate decisions, are of vital importance and signal the future path of monetary policy to the public. While for the interest rate signal this result is very obvious, the relevance and the ability of the introductory statement to guide markets is still scant. Above that we are able to make some qualifications. First, deeds are (only) slightly more relevant compared to words. Second, if there is no direct policy change the communication instruments complements the actions taken earlier and becomes more important. Finally, the impact varies with the inflation rate, market uncertainty and the position in the interest rate cycle. Notably, one has to keep in mind that the latter set of results is based on one complete interest rate cycle.

4.4 Conclusions

In this chapter we investigate how the ECB guides the expectations of the public. Via a novel approach we are able to infer how much weight the public places on the interest rate signal relative to the communication signal when it comes to predicting the next interest rate decision of the monetary authority. We proxy expectations by the judgement transmitted by media releases. As it is costly for the general public to evaluate the monetary policy decision by themselves it is likely that they update their expectations by reading newspapers. We conclude that both instruments are important tools to guide market expectations. Nevertheless, the interest rate signal outperforms. However, not as much as one could expect. While the interest rate signal is significant in *all* specifications, its impact is not necessarily bigger than that of the communication signal. Thus

[11] Blinder (1998) especially highlights the consequences of so-called policy reversals.

Table 4.3: Conditioning Effects

	(1) $EUCPI < 2$	(2) $EUCPI > 2$	(3) $EUCPI$	(4) Δi-cycle	(5) $\Delta i = 0$	(6) $\Delta i < 0 \vee \Delta i > 0$	(7) Δi vola
Δ Comm All	1.141***	0.900	0.592	1.212***	1.557***	1.119***	1.935***
	(0.369)	(0.842)	(0.708)	(0.315)	(0.367)	(0.325)	(0.711)
Δi	1.100***	0.974***	0.925***	0.670*			2.126**
	(0.312)	(0.257)	(0.242)	(0.406)			(0.873)
vola*Comm							-0.270
							(0.183)
vola*i							-0.306
							(0.213)
$\Delta i < 0$						-1.429**	
						(0.558)	
$\Delta i > 0$						2.828***	
						(0.559)	
step				-0.200			
				(0.146)			
step*Comm				-1.134*			
				(0.579)			
step*Δi				0.112			
				(0.134)			
highinfl*Comm			0.239				
			(0.388)				
highinfl$*\Delta i$			0.629				
			(0.789)				
Constant	-0.181	-0.163	-0.289*	-0.288*	-0.348**	-0.289*	-0.345*
	(0.238)	(0.226)	(0.161)	(0.160)	(0.169)	(0.160)	(0.177)
Obs.	33	25	64	64	50	64	64

Robust standard errors in parenthesis; ***/**/* denote the 1/5/10%-significance level

Table 4.4: Expectations and Type

	(1) Journalists	(2) Other	(3) ECB
Δ Comm All	0.868**	0.769	1.631***
	(0.346)	(0.555)	(0.526)
Δi	1.065***	0.934***	1.263***
	(0.256)	(0.298)	(0.414)
Constant	-0.430***	-0.159	0.013
	(0.154)	(0.248)	(0.332)
Obs.	52	37	24

Standard errors in parenthesis; ***/**/* denote the 1/5/10%-significance level

and in line with, for instance Ehrmann and Fratzscher (2007b), we find new evidence that not necessarily deeds matter more than words.

With respect to communication, especially information with respect to price developments seems to be of major importance. Moreover, at the beginning of the interest rate cycle as well in a situation where no interest rate change took place central bank communication via the introductory statement becomes an important ingredient in expectation formation. Notably, surprises, as measured by the difference between the interest rate change and the figures delivered by the Reuters survey of professional forecasters, have only a low informational value. A surprise might immediately disturb the precision of the expectations of the public or may result in a situation of substantial state uncertainty. Overall, we get some compelling result shedding light on the driving forces of expectation formation in monetary policy.

Part II

Media, News and the Economy

CHAPTER 5

News and Business Cycle Comovement

5.1 Introduction

One of the stylized facts of business cycles is that output in most sectors increases and decreases together, a phenomenon known as industrial or sectoral comovement. Although this is an important feature of business cycles, macroeconomic research has not yet found a fully sufficient explanation for it. For instance, Christiano and Fitzgerald (1998) stress that *"...explanations for this comovement (...) [are] still not satisfactory"*. Also Hornstein (2000) notes that *"...the problem clearly has not been addressed successfully"* and recently this was re-emphasized by Rebelo (2005) who writes that *"exploring the comovement properties of business cycle models is an important, but under-researched topic in macroeconomics"*.

This chapter will focus on one explanation for business cycle comovement which is put forward by Veldkamp and Wolfers (2007). They argue theoretically that many firms rely on similar information which implies that their actions are more similar as if they were in the full information scenario. We intend to validate to which extent such information complementarities drive business cycle comovement empirically.

This Chapter is based on Lamla et al. (2007).

Some of the earlier explanations claim that sectoral comovement must be driven by relatively strong aggregate shocks (Lucas, 1977), which are likely to be the primary source of business cycles.[1] However, the explanation put forward by Lucas has been questioned in the more recent literature. For example, Hornstein (2000) shows that the observed comovement in output cannot be explained by basic real business cycle models without having employment moving in the opposite direction in different sectors. However, this does not match reality. Instead a strong comovement across sectors also in terms of employment, investment and value-added exists and has been documented by Hornstein (2000), Christiano and Fitzgerald (1998) and Murphy et al. (1989).

Also the still puzzling fact that there is significantly less comovement of industry total factor productivity (TFP) than of industry output and labor input (Hornstein, 2000) suggests that aggregate productivity shocks cannot satisfactorily explain comovement and business cycles in general.

Alternative explanations of business cycle comovement are given by assuming complementarities. Such strategic complementarities arise when the optimal action of one agent is an increasing function of the actions taken by others. These models provide a basis for generating a positive comovement in sectoral activity and employment as described in Cooper and Haltiwanger (1996).[2] Veldkamp and Wolfers (2007) show that one can explain both the high comovement of output and the lower comovement of total factor productivity (TFP) when complementarities in information acquisition are present.

The role of news as a driving force for expectations and their important role in business cycles have already been noted by Pigou (1927). However, real business cycle models that give a theoretical foundation for expectation-driven business cycles have only quite recently been developed by Beaudry and Portier (2004). In a neoclassical growth model Jaimovich and Rebelo (2006) show that news about future TFP or investment-specific technical change can generate business

[1] Lucas argues that if the economy is subject to a large number of industry-specific disturbances which are unrelated to each other, one would expect that these disturbances change the relative productivity levels of inputs. This change in relative productivity levels should lead to a reallocation of inputs. Hence, input use should decline in sectors with falling relative productivity levels and should rise in sectors with rising relative productivity levels. However, the observation that there is a strong comovement across sectors contradicts this assumption of industry-specific disturbances; therefore one tends to conclude that business cycles are rather due to aggregate disturbances that affect all sectors of the economy. See Hornstein (2000).

[2] See also the review in Christiano and Fitzgerald (1998). They also point out that such complementarities can drive expectations, lead to self-fulfilling prophecies and are consequently another source for business cycle movements. See also Cooper and Andrew (1988), Benhabib and Farmer (1996) and Schmitt-Grohe (1997), amongst others.

cycles with volatility, comovement, and persistence of aggregates that are empirically plausible.[3] The introduction of news in their model can generate recessions and expansions only by affecting expectations about future fundamentals.

However, we concentrate on an argument put forward by Veldkamp and Wolfers (2007). The punchline of their model is that if firms observe the same information, they take more similar action. Why should this kind of equilibrium exist? They argue that information about a firm's idiosyncratic productivity is unknown to the firm and costly to obtain. For example, a firm has to pay for a forecast of the specific sector a firm is operating in or even the idiosyncratic state of the firm and its specific economic outlook. Moreover, information has high fixed costs of production and marginal cost of replication. As this information is non-rival in consumption other companies may easily identify the new information and mimic the actions, thereby reducing the advantage of the additional information and the reservation price. On the other hand, information about forecasts of economic aggregates such as aggregate production or consumption is available for free or at very low average cost, as this information is useful to all companies. Moreover, companies can partly deduct their own sectoral forecast from the aggregate forecast. Thus, an equilibrium emerges which consists of firms demanding only aggregate information trying to infer their sector-specific information from this. As all agents receive the same signal, their behavior is correlated, even if the underlying states of nature are independent. Hence, complementarities in information acquisition can be an explanation for the observed comovement.

Overall, this line of argumentation seems plausible. In reality, it is easier to obtain information on economic activity of the whole economy as on individual sectors. For instance, several research institutes compete in providing forecasts about the economic outlook meeting high standards. On the other hand, there is only little activity in sectoral forecasts. This implies that obtaining reliable sectoral forecasts is a much harder task.

The aim of this chapter is to empirically validate the theoretical model presented by Veldkamp and Wolfers (2007) and test whether news can indeed affect firms' expectations and perceptions, and, more specifically, whether aggregate information is the dominating source of information.

For this purposes we employ data on perceptions and expectations of companies as gathered by the Ifo Institute as well as a new data set that allows to quantify news made public using data on

[3] They introduce three elements in the model. First, variable capacity utilization increases output in response to news about the future. Second, adjustment costs to investment give incentives to react immediately to expected future technical progress. The third element is the assumption of preferences that allow for a time-varying wealth effect on labor supply, which implies a rise in hours worked in response to positive news about future TFP.

media reporting. The latter data is kindly provided by Mediatenor, a media research institute. Our analysis rests on a comparatively long data series comprising 01/1998–07/2006 using up to 618 available observations. We argue that most of the information a company builds on is provided by various media sources like television or newspaper. For instance, if new figures of GDP or inflation are made public by statistical agencies their implications are intensively discussed on television as well as in newspapers.

Our findings support models in line with Beaudry and Portier (2004) and Jaimovich and Rebelo (2006) as we show that media reporting indeed affects firms' assessment of their economic outlook. In turn, these expectations have explanatory power for future and actual economic developments.

Furthermore, we find evidence that firms in different sectors react more to news on the whole economy as compared to reports on their own sector. To analyze this, we aggregate all news that come through the media at the point of time where the surveys are send to the companies. Then we check how these news on the whole economy as well as on sector-specific developments impact expectations and perceptions of companies.[4]

As information on aggregates drives the future outlook of firms in a given sector more than news about their own specific sector, the mechanism described in Veldkamp and Wolfers (2007) that firms' inferences are based on common information, generating the observed excess comovement in sectoral output, compared to sectoral TFP, is supported by our findings. We conclude that information complementarities can be an important explanation for business cycle comovement. Finally, we investigate the impact of each sector individually and find strong heterogeneity between the different sectors. These might be explained by different degrees of reliance on information and proneness to shocks. We argue that this dependency on aggregate information might be especially driven by factors like the correlation of sector productivity with aggregate productivity respectively the volatility of productivity growth. For instance, if the sector-specific correlation with the whole economy is high, it is very beneficial and efficient for a company to rely on news on the whole economy to infer their own productivity growth. The reservation price for investing in sector-specific information would be very low, as the company can easily infer the relevant information from news on the whole economy.

[4] As we aggregate over a time period where the expectations measure is not publicly available there cannot be any impact of the publication of the expectations/perceptions index on our news indices.

The remainder of this chapter is organized as follows. Section 5.2 describes some stylized facts. Section 5.3 discusses the data in some detail, while Section 5.4 presents our model and the estimation approach. Section 5.5 reports our empirical results. The final section concludes.

5.2 Stylized Facts

We use simple correlation analysis to check whether the stylized facts reported for the U.S. also are present in German data. For the U.S. it is observed that the comovement between sector output is, for many sectors, stronger than the correlation between sector productivity. This phenomenon is labelled as excess comovement.

The firm's output decision is based on the equality of marginal returns and marginal costs. If the firms observe their own productivity and optimize their output decision accordingly, they should adjust their output growth in line with their productivity growth. If productivity increases the optimal response is, everything else equal, to generate more output. Thus, the sector-specific output comovement should correspond to the sector-specific productivity comovement.

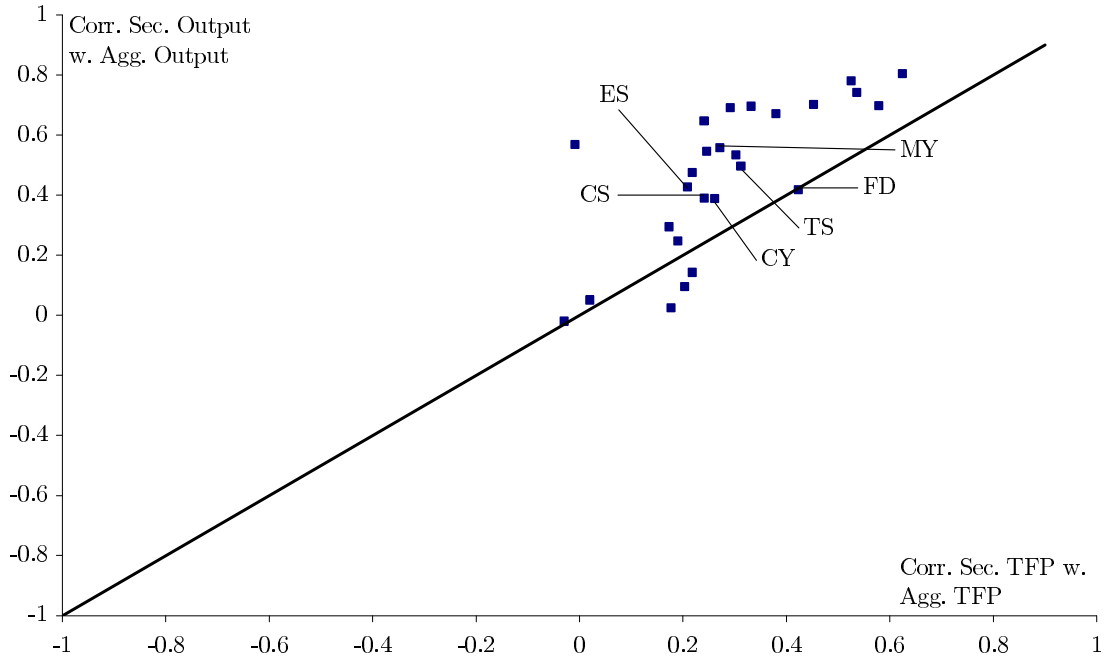
To investigate this issue for Germany we rely on data from the Groningen Growth and Development Centre—industry growth accounting database.[5] It comprises the time span 1980–2003.

We visualize the issue in Figure 5.1. It depicts the correlation over time of both output growth for each sector with the economy's aggregate output growth (output comovement, Y-axis) and the sectoral total factor productivity growth (TFP) with the economy's aggregate TFP growth (productivity comovement, X-axis). At the 45-degree line the sectors' output comovement corresponds with the sectors' productivity comovement. In case a sector has a higher output comovement than productivity comovement, i.e. it is located above the 45-degree line, this sector exhibits excess comovement.

Indeed, Figure 5.1 shows that also for Germany an excess comovement is present. Many of the sectors are located above the 45-degree line, which implies that output comovement is higher than productivity comovement. In the upcoming analysis we will concentrate on six sectors. These sectors are Chemistry (CY), Electrics (ES), Cars (CS), Machinery (MY), Food (FD) and Textiles (TS). Except for Food all sectors exhibit the pattern of excess comovement. One could argue that the informational need in the food sector might be less pronounced as volatility as well as productiv-

[5] Source: Groningen Growth and Development Centre, Industry growth accounting database, accessed September 2006, `http://www.ggdc.net/`.

Figure 5.1: Comovement of Output and Productivity



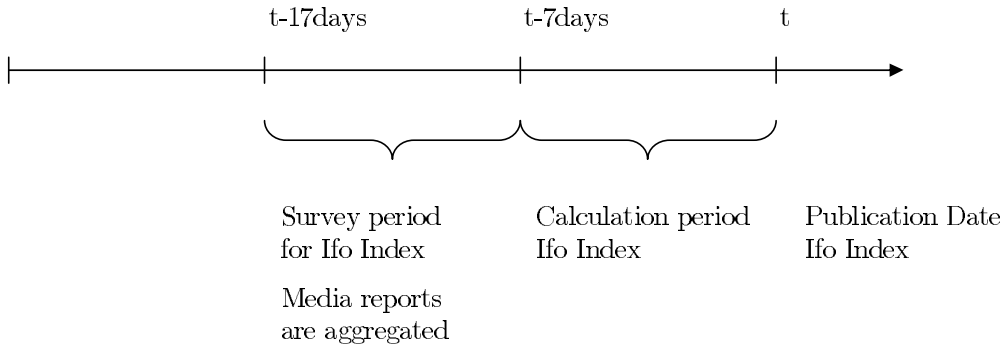
Solid line: 45-degree line. X-axis: correlation sector TFP growth and economy TFP growth, Y-axis: correlation sector output growth and economy output growth. Sector codes: Chemistry (CY), Electrics (ES), Cars (CS), Machinery (MY), Food (FD) and Textiles (TS). Source: Groningen Growth and Development Centre, Industry growth accounting database, accessed September 2006, `http://www.ggdc.net/`.

ity growth are comparatively small and therefore the gains from acquiring new information and forecasts are comparatively low.

5.3 Data

Our analysis requires two sources of data. On the one hand, we need data on expectations and perceptions to monitor the current and expected state of business. For this purpose we employ survey data as published by the Ifo Institute for Economic Research to measure the economic

Figure 5.2: Timeline of the Construction of the Media Indices and the Ifo Index



sentiment and business expectations. On the other hand we need data that capture the information that is disseminated at a certain point in time. In order to be able to capture this, we utilize information that is spread by news magazines, newspapers and TV broadcasts. This media data is kindly delivered by Mediatenor, a media research institute. All measures are available on the economy level as a whole as well as on a sector-specific level.[6]

Each month, the Ifo Institute sends a survey to nearly 7,000 firms in the sectors industry, construction and (retail and wholesale) trade all over Germany (Nerb, 2004). In general, this so-called Ifo Business Survey intends to capture the firms' appraisals of the business situation and their short-term planning and expectations. For instance, it asks firms to judge their current business situation, tendencies in production volume against the previous month, and business expectations for the next six months.[7]

Firms are invited to answer most of the questions on a three-category scale: 'good/better', 'satisfactorily/same' or 'bad/worse'. The replies are weighted according to the importance of each firm and its industry, and aggregated. The percentage shares of the positive and negative responses to each question are balanced (ignoring the answer 'satisfactorily'). In this way each qualitative question is converted into a single Ifo indicator.[8]

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[6] As we consider only the manufacturing sector there is a clear difference between averaging over all sectors employed in our study and the economy level indicator.

[7] For more detailed information, we refer to Oppenländer (1997) or Sturm and Wollmerhäuser (2004). See Theil (1955) or Strigel (1990) for an earlier appraisal.

[8] The series of balances thus derived are linked to a base year (currently 1991) and seasonally adjusted.

The well-known Ifo Business Climate Index combines the assessment of the current business situation and business expectations for the next six months.[9] We will use the same two questions in this analysis to see whether news reports in the media affect the way in which firms assess the current business situation and whether these news reports change their expectations about future developments of the business climate of their own product line.[10]

In our analysis, we concentrate upon the manufacturing sector, which takes up by far the largest part of the Ifo Business Survey.[11]

The media data captures the number of articles and media releases on a daily frequency since 1999, including statements about the economy at an aggregate as well at a sector-specific level. According to its standards, Mediatenor captures news which are at least five lines long in case of printed media or last at least five seconds in the case of television reports. We rely on news reports stemming from 26 newspapers, weekly magazines and TV broadcasts.[12]

The classification used in the media data allows us to focus on the developments of the six sectors, i.e. Chemistry, Electrics, Cars, Machinery, Food and Textiles.

To allow comparison with the Ifo data, we focus on the balance between positive and negative news. Hence, we are left with various media indices capturing the transmitted evaluations of current and future developments for the whole economy as well as for individual sectors.

Figure 5.2 visualizes the construction of the media index with respect to its aggregation in time. Usually the Ifo Business Climate Index is made public at the end of each month (i.e. between the 18th and the 24th of a month). Since it takes several days for the Ifo Institute to construct it, we assume the firms have already submitted the questionnaire a week before. For the same

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[9] To be precise, it is the geometric mean of the indicators derived from the balances to the question: 'We judge our current business situation for product group XY to be good, satisfactorily, or bad', and the question: 'With respect to the business cycle, our business situation for product group XY is expected to be somewhat better, more or less the same, or somewhat worse in the next six months.' Note that both questions refer to the 'business climate' and do not explicitly ask for developments in profits, or production. How the term 'business climate' should be interpreted is left open to the individual firms. Nevertheless, it is generally acknowledged that these qualitative results give a good indication of how actual industrial production evolves over the time.

[10] Hence, rather than focusing on the forecasting ability of Ifo Business Survey indicators, as is often done in literature (see, e.g. Fritsche and Stephan, 2002 and Hüfner and Schröder, 2002), this chapter uses these indicators as direct measures for firms' sentiment and assessments of their own future development.

[11] We blend out the retail and wholesale part of the trade sector and the construction sector. The main reason is that we do not have data from Mediatenor on news reports covering these sectors.

[12] In detail following news sources are analyzed: Daily press: Frankfurter Allgemeine Zeitung, Welt, Süddeutsche Zeitung, Frankfurter Rundschau, Tageszeitung, Bild, Neue Züricher, Berliner, Volksstimmer, Sächsische, Westdeutsche Allgemeine Zeitung, Kölner Stadt-Anzeiger, Rheinischer Merkur; daily TV-News: ARD Tagesschau, Tagesthemen, ZDF Heute, Heute Journal, RTL Aktuell, SAT.1 18:30, ProSieben Nachrichten; Weekly Press: Spiegel, Focus, Die Woche, Wochenpost, Welt am Sonntag, Bild am Sonntag, Die Zeit.

Table 5.1: Summary Statistics – Individual Sectors and the Economy

Variable	Mean	Std. Dev.	Min.	Max.	Observations
News Economy (n^{ag})	-23.7	18.1	-64.2	21.0	89
News Cars	6.1	11.1	-27.3	30.5	89
News Chemistry	6.9	12.2	-28.1	34.8	89
News Electronics	5.6	11.4	-23.5	33.6	89
News Food	-1.0	15.4	-53.3	27.0	89
News Machinery	4.9	14.8	-55.1	33.3	89
News Textiles	15.3	17.8	-20.0	66.7	89
Ifo Situation Cars	16.3	15.0	-10.0	47.0	103
Ifo Expectations Cars	7.0	19.6	-35.0	58.0	103
Ifo Situation Chemistry	9.9	15.1	-18.0	47.0	103
Ifo Expectations Chemistry	10.4	13.7	-26.0	35.0	103
Ifo Situation Electronics	-3.4	18.8	-35.0	32.0	103
Ifo Expectations Electronics	6.4	15.5	-35.0	38.0	103
Ifo Situation Food	-9.2	7.2	-29.0	9.0	103
Ifo Expectations Food	-2.6	8.0	-29.0	17.0	103
Ifo Situation Machinery	1.7	17.3	-30.0	45.0	103
Ifo Expectations Machinery	4.1	13.7	-33.0	27.0	103
Ifo Situation Textiles	-23.0	14.7	-48.0	6.0	103
Ifo Expectations Textiles	-6.3	12.3	-40.0	16.0	103

ten days during which firms fill out the Ifo Business Survey, we accumulate the media reports and construct our media indices. Hence, we assume that survey participants are especially affected to news transmitted during the period in which they fill out the forms.[13] Because the Ifo Business Climate Index is made public one week later, by construction there cannot be any contemporaneous impact running from the publication of this indicator to our constructed news indicator. This fact also has direct implication for our estimation approach which will be explained in the following section. Thus, keep in mind that the media index refers to the same point in time as the Ifo index. However, as the Ifo index is unknown to the public, because it is published one week later, it is clear that media causes the Ifo index and not vice versa.

[13] As a robustness check, we also construct media indices using data covering the full month. However, this does not alter the results qualitatively.

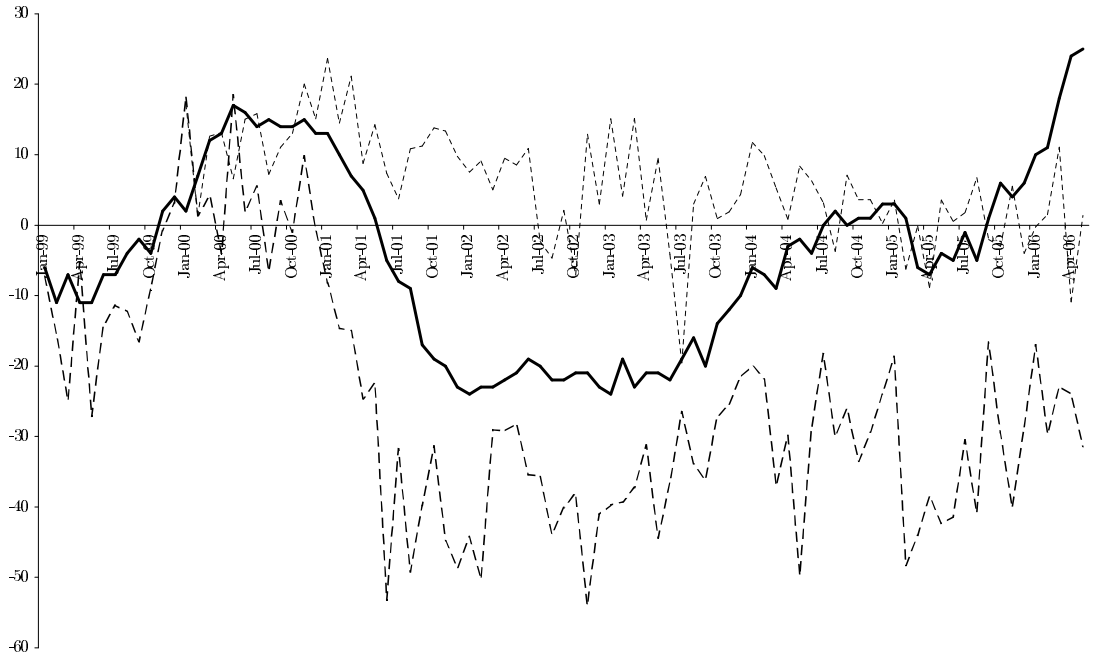
Table 5.2: Summary Statistics – Panel

Variable	Mean	Std. Dev.	Min.	Max.	Observations
News Economy (n^{ag})	-23.7	18.1	-64.2	21.0	612
News Sector (n_t^{sec})	6.3	14.7	-55.1	66.7	534
Ifo Situation (i^s)	-1.3	19.8	-48.0	47.0	618
Ifo Expectations (i^e)	3.2	15.3	-40.0	58.0	618

In Tables 5.1 and 5.2, we present the summary statistics. Table 5.1 offers the individual time series characteristics, while Table 5.2 refers to the stacked series used in the panel VAR analysis. The statistics are pooled results over all six sectors in our data. By construction, each variable can fluctuate between -100 and 100, where positive values indicate on balance more positive than negative assessments and vice versa.[14] When facing the data it becomes evident that the media reporting on the economy as a whole is, with an average value of -23.7, biased downward. Hence, these media reports have on average a rather pessimistic undertone. In contrast, media reports on sector-specific developments do not reveal such a pattern and seem more neutral in that respect. Looking at both the extreme values and the standard deviations, it becomes clear that all series face similar degrees of volatility. Figure 5.3 visualizes the movement of the Ifo Situation index in comparison to our aggregate news measure and the average sector-specific news measure. All three series are clearly correlated. The aggregate media index seems to be slightly more volatile compared to the sector-average news index. Moreover, both indices show a low degree of persistence in comparison to the Ifo Situation index. This is as expected. First, while the Ifo index is filtered, our series are raw and not adjusted. Second, the world is not changing that rapidly from one month to another and thus the overall sentiment should be less volatile as the media index. Not all stories which are made public and are incorporated in our news index are relevant and should affect the decision making process alike. Thus, only a certain essence matters for their actions.

[14] Although our variables are bounded there is little merit in applying the log-odds transformation, as the mass of observations is concentrated and more than two standard deviations away from the bounds.

Figure 5.3: Media Indices and the Ifo Situation Indicator



Solid line: Ifo Situation indicator; dashed thick line: media indicator whole economy; dashed thin line: media indicator sector average.

5.4 Model and Estimation Approach

To derive our empirical setup, we first sketch a simple model explaining as of how firms form their expectations. Let Ω^i represent the information set for firm i. This information set is decomposed into two subsets of information: information from the aggregate economy (ag) as well as sector-specific information (sec):

$$\Omega^i = \Omega^i_{ag} \cup \Omega^i_{sec}. \tag{5.1}$$

The information firm i has on the aggregate economy and on its own sector is a subset of the entire information available for, respectively the aggregate economy Ω_{ag} and the sector Ω_{sec}:

$$\Omega^i_{ag} \subset \Omega_{ag}, \tag{5.2}$$

$$\Omega^i_{sec} \subset \Omega_{sec}. \tag{5.3}$$

As described in the introduction, the main feature of the model of strategic information complementarities is that sector-specific information is very costly to obtain. Information on the aggregate economy, however, is available for free or at very low costs. One example would be publicly or privately founded research institutes who do research on the economy and make their results freely available. Those results are usually edited by media companies and made public. Therefore, a firm is likely to inform itself on aggregate developments via the media. The information it observes on its own sector is to a much smaller extent available as it is much harder to obtain. First it is a greater effort to conduct research on a specific sector (data availability, etc.) and second there is much less demand for this information, which implies that there are lower incentives or much higher costs for institutes to generate this information.[15] Especially, if we consider that information is non-rival in consumption and has marginal cost of replication, then the sector-specific information set is unlikely to be fully revealed. We label this observable part Ω_o:

$$\Omega_{sec} = \Omega_o \cup \Omega_u. \tag{5.4}$$

The unobservable part, Ω_u, has to be derived from other sources. As the economy-wide outlook also contains information for each sector ($\Omega_{ag} \cap \Omega_u$), a firm might, for instance, use the media information on aggregate developments available to "guestimate" the sector-specific unobservable part. In that case, this implies

$$\Omega^i_{sec} = \Omega^i_o \cup \Omega^i_{ag}. \tag{5.5}$$

Thus, a firm i forms its future output decision based on its own information set about sector-specific and aggregate productivity shocks:

$$E_t(y^i_{t+1}) = \alpha E_t(y^i_{t+1}|\Omega^i_{ag}) + \beta E_t(y^i_{t+1}|\Omega^i_{sec}) \tag{5.6}$$

$$\Leftrightarrow E_t(y^i_{t+1}) = \tilde{\alpha} E_t(y^i_{t+1}|\Omega^i_{ag}) + \tilde{\beta} E_t(y^i_{t+1}|\Omega^i_o). \tag{5.7}$$

[15] These costs become even more severe, if we think of generating this information on a high frequency, e.g. on a monthly basis.

To sum up, both sector-specific as well as aggregate information are important for making output decisions at the firm level. Although it might be argued that the 'true' sector-specific information is more important for a firm's production plan, this information is costly to obtain and the observable part might be incomplete, imprecise or simply too costly to be ordered every month.[16] To the contrary economy-wide information is provided (almost) freely as several research institutes provide accurate and reliable forecasts on future output and inflation. Their forecasts are subject to an intensive debate and thus catered by various media agencies. This implies that a firm's production decision will in practice rest largely upon aggregate information provided by the media. The more important this information channel is, the larger the effect of economy-wide media information will be on production plans of firms.[17]

We employ a type of the so-called Granger causality analysis to investigate the importance of media information on the assessment of current and expected business. In that way, we provide evidence with respect to the strategic complementarities hypothesis. To make our main hypothesis testable, we restate it to the following: The balance between positive and negative news is said to 'Granger cause' the assessment of the business climate and/or business expectations, if the time-series prediction of the Ifo indicators from their own past can be improved by adding lags of news balances to the equation. This interpretation of causality is, of course, intuitively attractive. It has therefore become widely accepted, although some of its implications are still under debate.[18]

Simple Granger-causality analysis may be obstructed by simultaneity effects: news may Granger cause business expectations, while at the same time the business situation causes news. To avoid this problem, we analyze Granger causality in a so-called 'Vector AutoRegression' (VAR) model. VAR methodology resembles simultaneous-equation modelling in that several endogenous variables are considered together. In a VAR, only endogenous variables enter: each variable is explained only by its own lagged values and the lagged values of the other endogenous variables. If necessary, deterministic variables, such as a constant or a trend, are included. As no conditions concerning the causal relationship of the variables need to be identified *a priori*, the simultaneity problem thus becomes solved. Since we are also interested in the direction of causality, this is a clear advantage.

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[16] One could argue that sector-specific news are provided via informal channels, like discussions with other companies, etc. The drawback of this channel is, however, the reliability of this information and to which extent it may be readily and timely available.

[17] See also Veldkamp and Wolfers (2007) for a formal model.

[18] For an early overview of pros and cons of Granger causality, see Granger (1980).

Using our four variables of interest—Mediatenor news balances concerning sector news (n_t^{sec}) and news addressing the stance of the whole economy (n_t^{ag}), the Ifo Business Expectation indicator (i_t^e) and the Ifo Business Situation indicator (i_t^s)—gives the following VAR(p) model:

$$\begin{pmatrix} n_t^{ag} \\ n_t^{sec} \\ i_t^e \\ i_t^s \end{pmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \\ a_{30} \\ a_{40} \end{bmatrix} + \begin{bmatrix} A_{11}(L) & A_{12}(L) & A_{13}(L) & A_{14}(L) \\ A_{21}(L) & A_{22}(L) & A_{23}(L) & A_{24}(L) \\ A_{31}(L) & A_{32}(L) & A_{33}(L) & A_{34}(L) \\ A_{41}(L) & A_{42}(L) & A_{43}(L) & A_{44}(L) \end{bmatrix} \begin{pmatrix} n_{t-1}^{ag} \\ n_{t-1}^{sec} \\ i_{t-1}^e \\ i_{t-1}^s \end{pmatrix} + \begin{pmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \end{pmatrix}, \quad (5.8)$$

where, for $j, k = 1, \ldots, 4$, a_{j0} are the constants, A_{jk} are polynomials of order p in the lag operator L, and e_{jt} are independent and identically distributed disturbance terms such that the covariance matrix $\Sigma = E(e_{jt}e_{kt})$ is not necessarily zero for $j \neq k$.

Each equation in the system can be estimated by Ordinary Least Squares (OLS). Moreover, OLS estimates are consistent and asymptotically efficient if each has the same lag structure. Even though the errors are correlated across equations, system estimators do not add to the efficiency of the estimation procedure since the regressions have identical right-hand-side variables (Denton, 1978).

If the lagged values of the explanatory variable exert a statistically significant effect, then we have identified a Granger-causal impact (of a so-called strong form) (Kawai, 1980).

The Granger-causality testing procedure does not generally give us an estimate of the sign of the overall effect. In order to test whether there exists a positive or negative effect of one variable on another, we apply the neutrality test, in which we calculate the sum of the lagged values of an explanatory variable and test whether it significantly differs from zero (Zarnowitz, 1992, pp. 365–379). Hence, in this setting the analysis of a Granger-causal relation from news balances on the assessment of the (future) business climate boils down to testing whether each of the coefficients of the lag polynomials $A_{jk}(L) = A_{jk}^1, \cdots, A_{jk}^p$, specifically A_{31} and A_{41}, (A_{32} and A_{42}) in equation (5.8) differ from zero. If furthermore the sum of these elements is significantly different from zero, we know that news does have a long-run impact on the Ifo Business indicators. We estimate both the constrained and unconstrained systems as a whole and apply likelihood ratio tests.

As links between the equations hamper interpretation of individual coefficients, Sims (1980) proposes to analyze a VAR model by observing the reactions of the estimated system to different shocks over time. Just as an autoregression has a moving average representation, a VAR can be

converted into a Vector Moving Average (VMA). The VMA representation allows us to trace the time path of various shocks on the variables in the VAR system.

Because the error terms are contemporaneously correlated, shocks that hit the economy affect all variables in the current period. Consequently, it is not possible to single out the effect of a separate shock. A standard solution for this identification problem is to impose restrictions of some kind. We use the Choleski factorization, which implies an ordering of the variables from the most pervasive, i.e. a shock to this variable affects all the other variables in the current period, to the least pervasive, i.e. a shock does not affect any other variable in the current period. In this manner, some economic structure is imposed on the computation of the impulse-response functions. Unfortunately, there are many ways to order the variables (for k variables there are $k!$ orderings), and, as noted for example by Cooley and LeRoy (1985) and Duggal et al. (1995), the choice of one particular ordering might not be innocuous. Of course, the importance of the ordering depends on the magnitude of the correlation coefficient between the error terms. If the estimated correlations are almost zero, the ordering is immaterial. We order the variables (from most exogenous to most endogenous) as follows: Ifo Situation, Ifo Expectations, sector-specific media, economy media. To test for robustness, we have also changed the ordering. This did not change our conclusions.

To give an indication of statistical reliability, we report the impulse responses along with a 95 per cent confidence interval, using a computational procedure developed by Giannini (1992), which is based on asymptotic Gaussian approximations of the distribution of the responses.

Given that only data from 1999 onwards are available for this analysis, we use the above set-up in a panel data framework in which the constants in Equation (5.8) are replaced by sector dummies. We will focus on the manufacturing sector and using data for six different manufacturing branches. For further inference we will also investigate the responses to news on each sector individually.

5.5 Empirical results

Table 5.3 reports the statistics of the Granger causality and Neutrality tests. We opt for the Likelihood-Ratio test. However, the conducted Wald-tests lead qualitatively to identical results. We observe that there is a clear evidence that Ifo Expectations cause changes in the Ifo Situation index and not vice versa. This is as expected and reveals that the answers collected by the Ifo institute are genuine. Furthermore, we can see that news on the economy have a significant impact on

Table 5.3: Neutrality and Granger Causality Tests

Variable \ Equation	**Ifo Situation**		**Ifo Expectations**		**News Sector**		**News Economy**	
	Neutrality	Granger	Neutrality	Granger	Neutrality	Granger	Neutrality	Granger
Ifo Situation	0.000	0.000	0.393	0.748	0.454	0.332	0.004	0.0139
	(567.73)	(580.94)	(0.72)	(3.47)	(0.56)	(6.88)	(8.10)	(15.97)
Ifo Expectation	0.000	0.000	0.000	0.000	0.115	0.060	0.782	0.005
	(29.28)	(42.81)	(375.10)	(462.32)	(2.29)	(12.07)	(0.07)	(18.31)
News Sector	0.539	0.124	0.958	0.228	0.000	0.000	0.008	0.105
	(0.36)	(9.99)	(0.00)	(8.14)	(28.88)	(37.98)	(6.69)	(10.48)
News Economy	0.005	0.000	0.816	0.000	0.031	0.374	0.000	0.000
	(7.73)	(24.73)	(0.05)	(23.46)	(4.66)	(6.44)	(471.07)	(496.53)

Statistics based on Likelihood-Ratio tests. P-values reported. Chi-squared statistics in parenthesis. 'Neutrality' denotes the test of the significance of the sum of the coefficients while 'Granger' represents the statistics of joint test.

Ifo Situation as well as on Ifo Expectation while sector-specific news do not affect both indicators substantially. These results correspond with the model predictions. Media directly effects the the current perception of the economy but also is used to digest information for future business. Furthermore, firms use aggregate information to infer the future path of the economy. In addition, as the neutrality test is rejected, it seems there is a rather short-run effect of economy-wide news on expectations. While this analysis provides us with information concerning the significance and the direction of an impact of one variable on another, it gives no answer with respect to the time path of the impulse. Therefore, we additionally calculate the impulse response functions.

Figure 5.4 shows the impulse response functions. First and in line with the statistics reported in Table 5.3, Ifo Expectations have a significant impact on the actual business situation. The maximum impact is reached after about six months, the time horizon over which firms are asked to assess future developments. Which in turn implies that firms, on average, give coherent answers, being able to accurately describe their economic standing six months in advance.

Moreover, we can confirm that media indeed shapes the opinion and assessment of the current and future business situation; media affects both Ifo Expectations as well as Ifo Situation. This again confirms results of the significance test. Moreover, we can add to this that news dealing with the economy as a whole exhibit a stronger impact on the Ifo index than sector-specific news. This affirms the importance of information complementarities. Due to information cost, companies rely on aggregate data in order to infer sector-specific information.

It is generally found that the Ifo index captures real movements in the economy quite well (see Nierhaus and Sturm, 2007). This suggests that information transmission via the media has indeed an impact on the real economy and thereby drives business cycles and amplifies sector comovement.

In view of the heterogeneous character of the manufacturing sector, we estimate each sector individually. Figure 5.5 depicts the impulse responses to a shock of news on the whole economy and of sector-specific news. For the sake of brevity, we just report these impulse responses and not the full set of impulse responses for each sector.[19]

While on average there is compelling evidence in favor of our proposition that aggregate information has a strong impact, there is some degree of heterogeneity in the response to a news shock across the sectors. For instance, the food sector is neither influenced by news on the economy as a whole nor by news on its own sector. On the other hand, sectors like textiles, chemistry, cars

[19]That is, we concentrate on the A_{31}, A_{41}, A_{32} and A_{42} polynomials in equation (5.8). The full set of results is available on request.

and machinery exhibit a clear pattern that matches our ex-ante considerations and the general picture. Finally, sector-specific news have a very pronounced impact on the Ifo Situation index for electronics.

The different impact between these sectors may be explained by different needs for sector-specific information. This finding is consistent with the Veldkamp-Wolfers model. Firms make rational choices if they buy sector-specific information for a relatively high price or obtain only information on aggregate data for a relatively low price. If a firm in a given sector knows that the sectoral productivity developments are relatively close to the aggregate productivity developments, the loss of making decisions based on aggregate information only is lower than for firms that are in sectors where productivity developments are less synchronized. Hence, the loss of making decisions based on aggregate information is higher, the higher the difference between aggregate and sector-specific productivity developments. Another relevant aspect is the volatility of productivity growth. If it is high, there are higher costs associated with a mismatch between the actual output decision and the optimal output decision.

Thus, if this loss outweighs the costs firms have to pay for sector-specific information, they rationally choose to pay for obtaining this relatively costly information. This is also present in our results: for instance, the necessity of the food industry to base their decision on upcoming information is lower as food consumption patterns are quite stable over time and more importantly, the productivity growth of this sector is very low.[20] Hence, the incentives to react to incoming news concerning the performance of the economy is much lower than in other sectors.[21] Furthermore, we find support that sectors underlying rapid productivity growth and low correlation with the whole economy have more incentives to gather sector-specific information, because a deviation would be extremely costly. When facing the outcome of electronics, with an average TFP growth of six percent, we observe that a shock to sector-specific information has a more pronounced impact than an impact of economic news. In addition, this sector has the lowest correlation of sector productivity with economy-wide productivity.[22] The remaining sectors react more to economy-wide news.

Finally, we present a robustness check for our results. One could argue that we only capture actual shocks which are consequently reported in the media. Thus, we attempt to extract the effect

[20]TFP growth in the food sector is basically zero. Contrary, TFP growth of electronics is on average six percent. The average unweighted TFP growth over all sectors is about one percent.

[21]This is underlined by the low degree of volatility in this sector relative to the other sectors in our sample.

[22]Notably, the correlation of sector-specific productivity growth with economic-wide productivity growth is quite similar over all sectors considered in our study.

of current real economic events reported in the media. In order to control for that, we need to instrument our media indices with hard data on industrial production. That is, in a first stage our media data are regressed on both aggregate and sector-specific (ex post) industrial production growth in the same and the previous three months. We now interpret the residuals as news movements which are not backed up by actual real developments. Within the VAR framework, we now replace the original news variables by these newly constructed variables, 'News Economy' and 'News Sector'. As Figure 5.6 reveals hardly any changes emerge. Hence, information as distributed by the media appear to affect the firms' assessments of current and future developments.

5.6 Conclusions

Why are sector-specific developments highly correlated among each other? How come that sectoral comovement for output is stronger than for productivity? These are questions which we address in this chapter. Both issues will be answered by considering how much of these dynamics can be attributed to information complementarities.

Recent theoretical work by Veldkamp and Wolfers (2007) highlights the role of news as an ingredient in business cycle movements. They suggest that high costs for sector-specific information force industries to rely to a large extent on economy-wide information which is more readily available. From this information they infer the necessary information for their own sector. As this implies that firm specific actions are based on similar information, this can explain why the sectoral comovement is more pronounced in output as compared to productivity, an observation which also holds for Germany.

Using German survey data from the Ifo institute as well as data on German media reporting, we show that the media indeed shapes the perceptions and expectations. Moreover and more importantly, we find that economy-wide media information has a stronger impact on sector-specific business assessments than sector-specific media information has. This enforces theoretical models highlighting the role of news as an ingredient in business cycle movements. More specifically, our findings support the view of strategic interactions, driven by information acquisition aspects, as one source of business cycle comovement. Thus, information complementarities, as addressed by Veldkamp and Wolfers (2007), can give an answer to the above questions.

Finally, we observe that there is a significant heterogeneity between sectors. The marginal utility of information may vary between industries. For some industries it is more crucial to have

up-to-date and sector-specific information than for others. For instance, industries relying on huge investments, facing greater volatility or stronger competition might be willing to invest more in sector-specific information. In this chapter we have shown that information and more specifically information constraints affect expectations. The upcoming chapter will discuss the consequences of information constraints and processing capabilities in the case of forming inflation expectations.

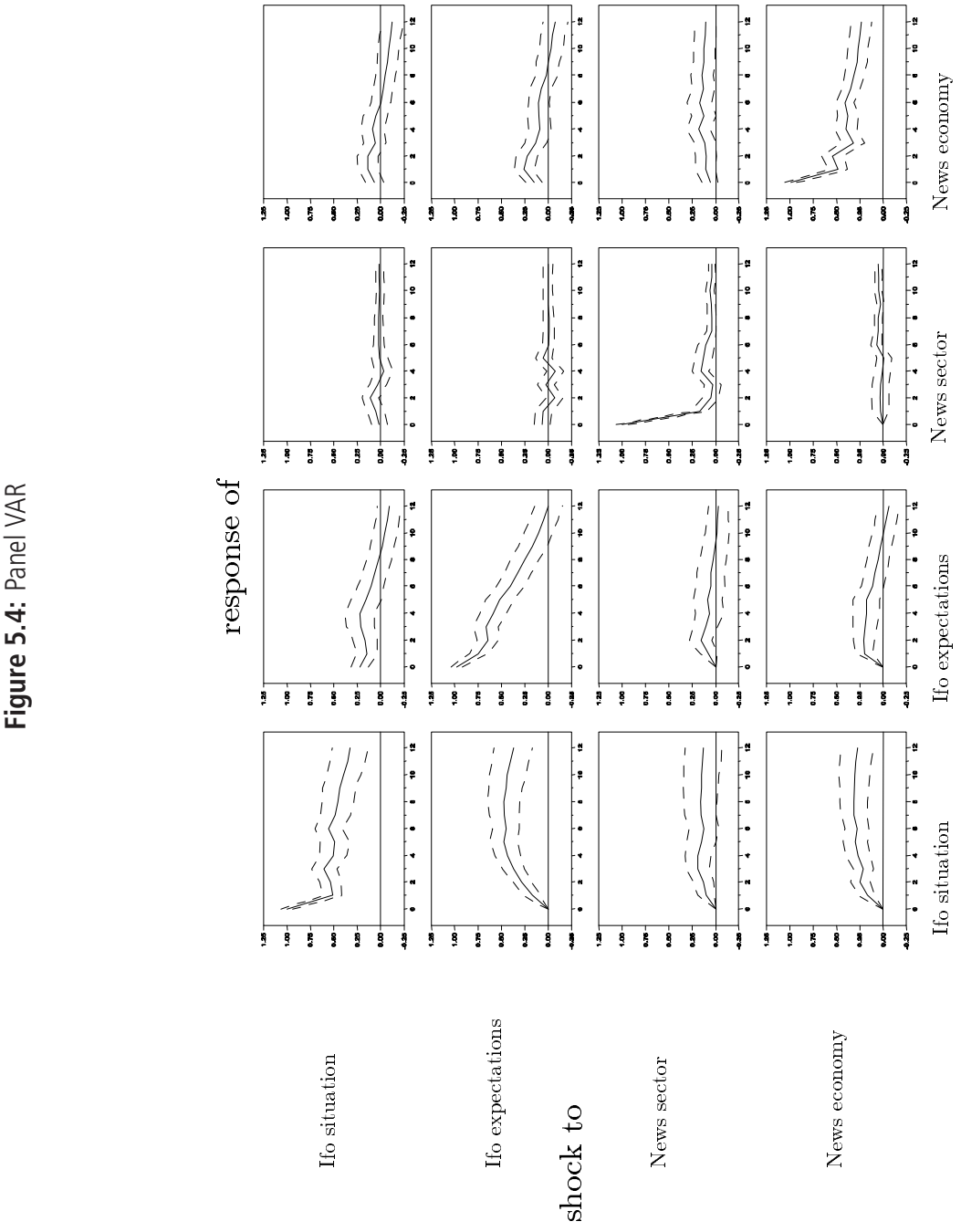


Figure 5.4: Panel VAR

Figure 5.5: Sector Specific VARs

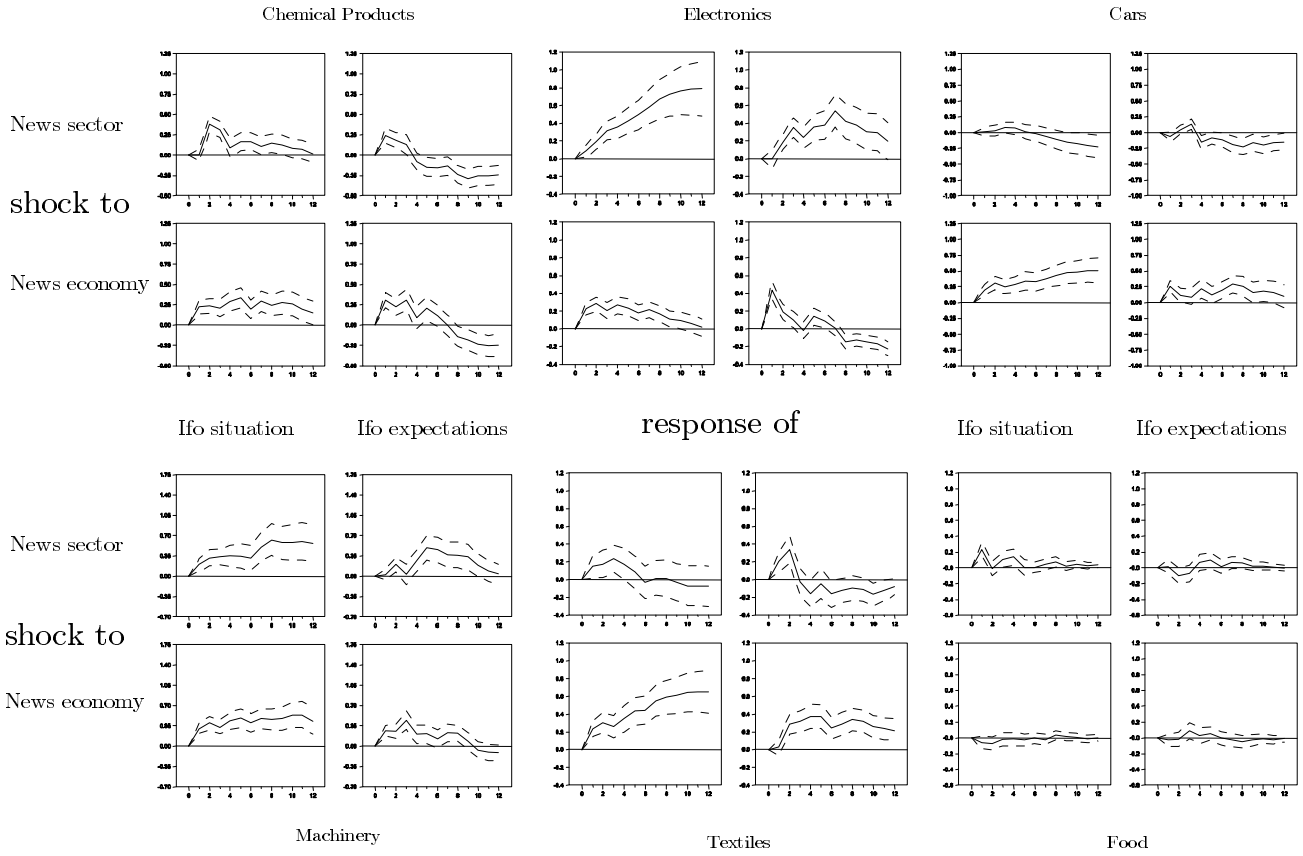
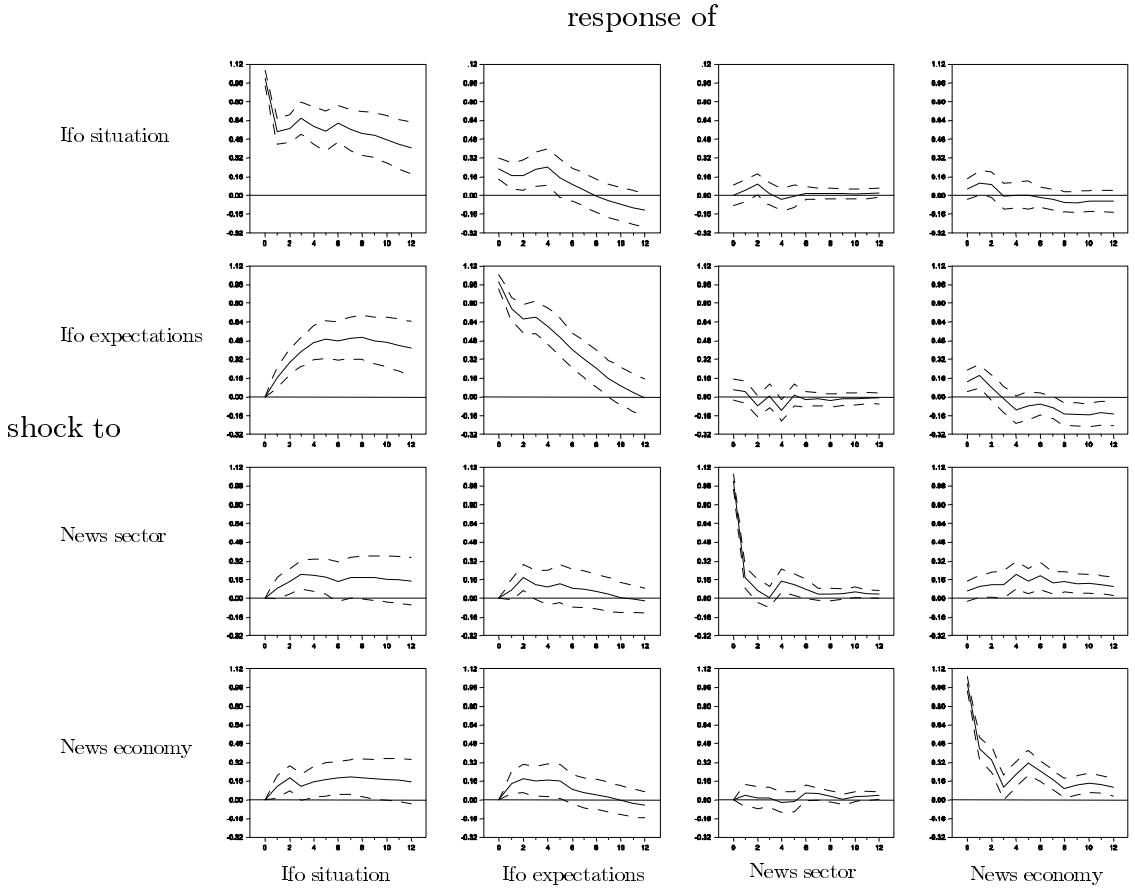


Figure 5.6: Two-Step VAR



Note, variables 'News Sector' and 'News economy' are being instrumented by industrial production.

CHAPTER 6

The Role of Media for Consumers' Inflation Expectations

6.1 Introduction

Controlling inflation is the main objective of central banks. Both theoretical considerations and empirical evidence show that inflation expectations are one of the key determinants of future inflation rates. Although central banks nowadays claim that managing consumers' inflation expectations has become one of their most important tasks, still very little is known about the way consumers form their expectations. This chapter adds to the understanding of consumers' inflation expectation formation by investigating the role of media as a transmitter and filter of news.

There is a keen interest in the literature to adequately capture expectation formation. Expectation modelling has moved away from assuming perfectly informed fully rational consumers to sporadically informed and rationally inattentive agents. Consumers are likely to posses only constrained information on current economic developments or limited capabilities in processing information.

A well-known theoretical approach by Mankiw and Reis (2002) develops the idea that information is sticky, which means that economic agents update their expectations only from time to

This chapter is based on Lamla and Rupprecht (2007b).

time. Outside their updating periods consumers are inattentive. One reason for this behavior may be an underlying convex cost function of information processing as proposed by Sims (2003) and Moscarini (2004). Mankiw et al. (2003) find support for the above hypothesis focussing on several inflation expectation surveys for the U.S. Those studies highlight two issues. First, people do not use all information available and second, due to the cost effect, they will rely on certain common sources in order to share costs of information acquisition. One such source clearly is the media that provide news relatively cheaply to everybody (Kwiek, 2006).

The approach followed in this chapter is related to Carroll (2003), who assumes that consumers update their inflation expectations from the media, which transmit rational expectations of professional forecasters to the general public. The assumption that consumers get their macroeconomic views from the news media instead of investing time into obtaining relevant information from other sources to form their views on the economy seems plausible.[1] Carroll finds that more frequent media reporting makes consumers' expectations more accurate as they update their beliefs more often than during times of less media coverage. This would imply that consumers' inflation beliefs are rational but they update their information only infrequently as in a Mankiw-Reis fashion, and hence not all consumers have the most actual information on inflation developments. Therefore, the higher the number of media reports on inflation, the more likely consumers update their beliefs and the closer they are to the rational forecast.[2]

A point Carroll does not address is the role the content of the statement plays. It is of great importance not only to account for the amount of news, but also monitor the message that is transmitted. Articles often discuss whether inflation is, was or will be rising or falling and thus people consuming the report will use the opinion transmitted to update their own judgment on this topic.

Therefore, we add a second dimension and distinguish *two* theoretical channels on how media reports may affect consumers' inflation expectations. First, in line with Carroll (2003) we argue that the intensity of reporting about inflation matters. This argument is incorporated in our *volume* channel. If newspapers and TV broadcasts deliver more reports on inflation this increases the likelihood that consumers become more aware of inflation and triggers an updating of their expectations on this issue. As a consequence this implies that consumers' forecast accuracy improves. Second, the *tone* of reporting gives consumers signals in which direction to revise their expecta-

[1] As information is non-rival in consumption and there are marginal costs of replication people have incentives to gather information from media than invest individually in research activity.

[2] For practical reasons a rational forecast is defined as the forecast of professional economists.

tions. The latter channel could also increase forecast accuracy if reporting is consistent with what we consider to be the rational forecast. However, the *tone* within the media can also induce a media bias by, for instance, exaggerating negative news relative to positive ones.[3] Hence, the quality of the media report decides about the effect the *tone* channel has on consumers' expectations: it can either improve accuracy if the quality of information provided by media is high or deteriorate the forecast accuracy if the media report is biased.

To test the impact of the proposed channels on the gap between consumers' inflation expectations and professional forecasters' expectations we employ a detailed media data set of news reporting on inflation comprising the period 01/1998–12/2006 in Germany on a monthly basis.[4]

We find statistical support for both channels: the number of reports on inflation leads to a tightening of the gap between consumers and professional forecasters' expectations. The tone within the report points towards the existence of a media bias: the share of news that report rising inflation relative to the share of news reporting falling inflation widens the gap. We also provide evidence that the relationship exhibits a different pattern during the phase of the Euro cash changeover, where also consumers' inflation perceptions displayed very unusual patterns (Lamla and Rupprecht, 2007). This finding is robust for different specifications. We show that agents are not backward looking but build their expectations on inflation on news with respect to the present and the future. Finally, we survey how the observed impact varies with the socioeconomic background. We provide evidence that older and more educated people are less prone to such a bias and for them the improvement of the *volume* channel is more substantial.

These findings have important implications: as inflation expectations are one of the main determinants of future inflation, our results suggest that media influence these expectations and thereby may influence future inflation. This raises the question how this would alter economic outcomes. Therefore, media could be seen not just as a transmitter of unbiased news but also as an economic actor.

The next sections are organized as follows. Section 6.2 derives the hypothesis we test. Section 6.3 introduces the data and the methodology we utilize. In Section 6.4 the results are presented and discussed while Section 6.5 concludes.

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[3] There is some evidence that indeed negative news are more often reported. See for instance Groeling and Kernell (1998) or Lamla and Rupprecht (2007a).

[4] We capture 26 newspaper and television channels.

6.2 Hypotheses

In this section we will discuss the role media plays in driving inflation expectations. We will recapitulate preceding studies and formulate our hypothesis.

News reports transmit new information to a broader public. In the transmission process, both the quantity and the content of stories matter. Hence, media can influence inflation expectations of consumers via two channels.[5]

The first channel is the *volume* or quantity channel. More news reporting provides information to consumers, makes them more attentive and triggers the updating of their expectations. If consumer face costs of acquiring, absorbing and processing information, consumers rationally choose to only sporadically update their information (Reis, 2006). It is unlikely that each consumer has full understanding of macroeconomic dynamics and constantly reviews the latest statistics to produce his own inflation forecast. Also not every person is able to read every article in the continuum of news provided every day. This implies that if there are many news stories on inflation within a given month, it is more likely that a consumer reads or watches these news, becomes aware of this specific issue and updates his information set that generates his expectations. Therefore, our first hypothesis is: *more media reporting brings consumers' forecasts closer to the rational forecast*.

Hypothesis 1 closely follows the line of argumentation in Carroll (2003): people are assumed to obtain their macroeconomic views from the news media. Not every person pays close attention to all macroeconomic news and therefore individual people are assumed to absorb the economic content of news stories probabilistically, so that it takes time for news of changed macroeconomic circumstances to be received by all agents in the economy. Carroll assumes that the media reports the views of professional forecasters, who themselves make rational forecasts. This would imply that consumers update their expectations with the rational forecast. This assumption, however, might, from our point of view, be overly optimistic and thus may not have general validity. Media companies may sometimes have incentives to twist or exaggerate certain developments. One could argue that media companies want to increase their profits by catering to the prejudice of the reader. In addition, the owners of media companies might also have some self interest.[6] In media

[5] Doms and Morin (2004) also incorporate both channels discussing the relationship between media reporting and consumer sentiment indicators.

[6] Gentzkow and Shapiro (2006b) discuss the relevance of ownership structure for the media slant in U.S. newspapers.

and political science research it is a common finding that media can transmit biased news to their consumers (Hetherington, 1996).

So far we have only focussed on the consequences of changes in the intensity of the coverage on a certain topic. However, the content of the reports is also of major importance. This is a point that Carroll does not take into account. Some empirical evidence for the claim that media shapes peoples' expectations exists. For instance, Berger et al. (2007) show that consumers' inflation expectations across the Euro area react to more favorable reporting on the ECB in the main newspapers. Doms and Morin (2004) show that news affect consumers perception on the economy by using the R-word index from *The Economist* measuring the frequency of the word "recession" in the media. The effect of the content, or tone, of the report can go in both directions, depending on the quality of reporting.

If the informational content of media reports is unbiased and of high quality, our indicator for the tone of the report should improve the forecast accuracy of consumers. Therefore our hypothesis 2a is: *the tone of the report brings consumers' forecasts closer to the rational forecast*.

If, on the other hand, the content of media reports is biased, the tone of the report impairs the accuracy of consumers' forecasts. As Hamilton (2004) notes, "news is a commodity, not a mirror image of reality" (p. 7). The reason for this may be the profit maximizing behavior of the media companies. In the decision process which news to transmit, media supply what is demanded: interesting and exciting stories. For instance, exaggerating bad news might be the profit maximizing choice from a media companies point of view. Hence, such news stories might well exaggerate actual developments to provide the story they need to sell. This would imply the existence of a so-called media bias, i.e. exceptional news may be overemphasized, distorted or fabricated to boost commercial ratings.[7] Anecdotal evidence taken from The Economist:"Journalists are writing us into a recession" (4th of October 2006) suggests that media may not only provide information but they might bias the impact of news on consumers' expectations in a certain direction. Empirical evidence for the existence of a media bias is provided in Shah et al. (1999), who find that the media give only little attention to the economy when it is in good shape but report extensively when it is in bad shape.[8] DellaVigna and Kaplan (2007) provide evidence that the introduction of biased news reporting has significantly affected voting in the U.S. Hetherington (1996) puts forward that

[7]Hamilton (2004) discusses the choices media have about the question which news to bring into their reports. He shows that "hard news" (such as facts about government and politics) become more and more replaced by "soft news" (human interest and entertainment figures) to give more return to media outlets.

[8]In a similar fashion see also Groeling and Kernell (1998).

media consumption and attention through the mass media negatively shaped voters' retrospective economic assessments in the 1992 election. Overall, these studies suggest that media play an important role in opinion making and also allow for the existence of a media bias.

If indeed consumers update their information sets by absorbing the content provided by the media, the existence of a media bias has obvious consequences for expectation formations. For instance, if in a given month fifty news articles report that inflation will go up and only ten state it will go down, consumers that form their views from the media are more likely to rather revise their expectations upward than downward. If no media bias existed, the tone of reports should bring consumer inflation expectations closer to the rational forecast. However, if there is a media bias present, the tone of reports could push away expectations from the rational forecast. We therefore test our hypothesis 2b: *the content and tone of media reporting impairs the accuracy of consumers' forecasts*. Notably, by exaggerating some news, thereby increasing the weight consumers give to it, the media would be able to drive away consumers' forecast from the rational forecast.

6.3 Data and Methodology

To analyze this issue we need data for inflation expectations of consumers and the rational forecasts of professional economists as well as a measure for the extent and content of inflation reporting by the media in a given period. For the latter we rely on data kindly provided by a media research institute, Mediatenor. The data comprises news articles and media releases on a monthly frequency for the time span 01/1998–12/2006 in Germany covering statements dealing with inflation which are at least five lines long in case of printed media and last at least five seconds for television broadcasts.[9] The data contain different specifications. We are provided with the overall number of reports in that given period, the amount on rising and falling inflation and whether the focus of the report was mainly the present, the past or the future.[10] The measure of news intensity (*Volume*) is simply the number of inflation reports within a given month divided by the maximum

[9] In detail following news sources are analyzed: Daily press: Frankfurter Allgemeine Zeitung, Welt, Süddeutsche Zeitung, Frankfurter Rundschau, Tageszeitung, Bild, Neue Züricher Zeitung, Berliner, Volksstimmer, Sächsische, Westdeutsche Allgemeine Zeitung, Kölner Stadt-Anzeiger, Rheinischer Merkur; daily TV-News: ARD Tagesschau, Tagesthemen, ZDF Heute, Heute Journal, RTL Aktuell, SAT.1 18:30, ProSieben Nachrichten; Weekly Press: Spiegel, Focus, Die Woche, Wochenpost, Welt am Sonntag, Bild am Sonntag, Die Zeit.

[10] The coding is based on the standards of the media research institute. Those people have a sound education in transforming the semantics into quantitative figures. Moreover, those people are trained to achieve a high correlation between different persons who code, so that the coding only has a minimum of individual judgment inherent.

number of reports. As the variable *Volume* contains all reports we opt to calculate the variable *VolumeNeut* excluding all statements that transmit a certain direction. With this variable we can infer whether the response is especially driven by articles on inflation in general. The measure for the *tone* is calculated by subtracting the share of news reporting rising inflation from the share announcing falling inflation. Furthermore, in order to control for asymmetries in the response to news on falling respectively rising inflation we construct a variable summarizing the share of reports on rising inflation (*TonePos*) and in a similar fashion *ToneNeg* denotes reports on falling inflation. Moreover, we are able to also count the news stories with regards to the time structure, i.e. whether the story is related to past (*TonePast*) respectively forward looking (*ToneFor*). They are constructed the same way as the overall *tone* measure, i.e. divided by the maximum of the specific series to bound the measures between zero and one.

Data on consumers' inflation perception and expectations are taken from the EU business and consumer survey on a monthly frequency. German consumers are being asked whether they expect prices to rise, fall or remain unchanged in the upcoming 12 months (expected inflation). We also employ disaggregated data based on socioeconomic characteristics like age, income, education and gender. Income level is divided into 4 quartiles, age is separated into four groups: 16–29, 30–49, 50–64 and 65+, and education is allocated into three groups: primary education, secondary education and further education. Inflation expectations for Germany from professional forecasters are constructed from Consensus Economics forecasts. In that survey, several professional economists are asked about the inflation prospects of the contemporary and upcoming year.

Following the approach of Carroll (2003), we measure the news index by dividing the number of stories on inflation in a given month by the maximum number of inflation stories in any year. The index ranging between zero and one is named $Volume_t$. To measure the deviation of consumers from an optimal forecast we calculate the absolute value of the gap between the consumers survey (C_t) inflation expectations and those of the consensus economics professional forecasters (P_t), i.e. $absGapExp = |(C_t - P_t)|$. To make the series comparable we standardize both series, C_t and P_t by dividing each observation by the series' own standard deviation. In the original specification Carroll used the squared gap. However, as this measure might overweight specific incidences we decided to employ the absolute gap. Notably, this does not lead to qualitatively different conclusions. The summary statistics of our variable set are given in Table 6.1. Note that the consumer inflation expectations figure is an index. Thus, the gap is not the difference in the inflation rates. The series of the gap between consumers and producers as well as our *tone* and *volume* measures are depicted in Figure 6.1.

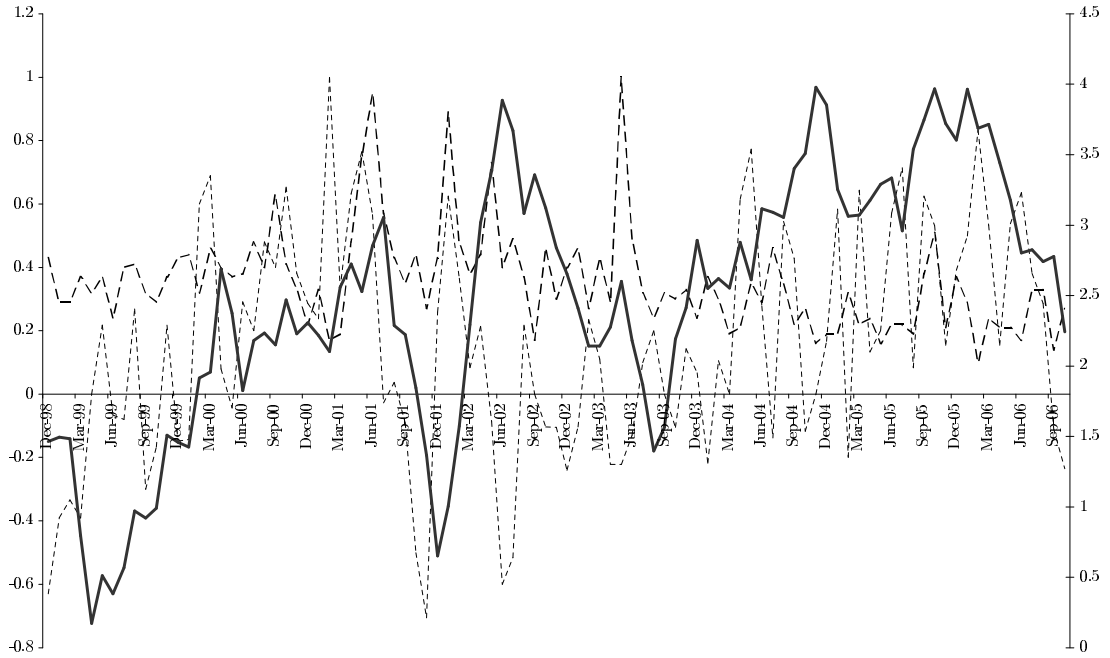
Table 6.1: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	Observations
absGapExpFemale	2.53	0.92	0.27	4.04	94
absGapExpMale	2.42	0.92	0.21	3.93	94
absGapExp65+	2.35	0.91	0.16	3.92	94
absGapExp50-64	2.40	0.88	0.19	4.02	94
absGapExp30-49	2.55	0.96	0.27	4.16	94
absGapExp16-29	2.65	0.92	0.27	4.48	94
absGapExpEdFurth	2.71	0.83	0.58	4.11	94
absGapExpEdSec	2.52	0.88	0.28	4.11	94
absGapExpEdPrim	2.42	0.99	0.00	4.22	94
absGapExpInc4Q	2.50	0.96	0.11	4.12	94
absGapExpInc3Q	2.30	0.91	0.13	3.91	94
absGapExpInc2Q	2.48	0.85	0.34	4.17	94
absGapExpInc1Q	2.26	0.86	0.24	3.88	94
absGapExp	2.47	0.92	0.17	3.98	94
Tone	0.16	0.36	-0.71	1.00	94
Volume	0.36	0.16	0.10	1.00	94
VolumeNeut	0.21	0.12	0.00	1.00	94
ToneFor	0.17	0.32	0.71	0.91	69
TonePast	0.18	0.53	-1.00	1.00	69
Exp Prof	1.47	0.60	0.10	2.80	94
ExpConsumer	23.4	12.2	5.20	46.5	94
ToneNeg	0.20	0.17	0.00	0.76	94
TonePos	0.36	0.22	0.02	1.00	94
Vol Teuro	0.10	0.19	0.00	1.00	94
Vol EuroCashChangeover	0.11	0.14	0.01	1.00	94

The deviation of consumers' from professional forecasters' inflation expectations should give us a good proxy of the deviation of consumers from the rational forecast. To see whether media reporting plays a role for the deviation of consumers inflation expectations from the rational benchmark, we estimate following equation via OLS controlling for serial correlation using Newey-West standard errors.[11] This specification is the same as employed in Carroll (2003) except that we lag our explanatory variable by one month. As noted before, he only considers what we call the *vol-*

[11]Newey-West standard errors are calculated using lag 3. The lag selection is set by the formula $lag = \lfloor 4(T/100)^{2/9} \rfloor$ where T is the number of observations. This formula is suggested by Newey and West (1994).

Figure 6.1: Media Coverage and Inflation Expectations Gap



Solid line: absolute gap between consumers' inflation expectations and inflation expectations of professional forecasters; thick dashed line: sum of all reports on inflation (*Volume*); thin dashed line: share of news of rising inflation relative to news on falling inflation (*Tone*). Left-hand scale: Media indices; right-hand scale: gap between consumers and producers.

ume channel: the more news reported the more likely are consumers to update their information set. Therefore, we employ the news measure of news intensity, i.e. all inflation reports, without considering its content (*volume*). To test for the influence of the news volume we estimate the Carroll equation

$$absGapExp_t = \alpha + \beta Volume_{t-1} + \varepsilon_t. \tag{6.1}$$

Alternatively, we consider a second information that might be important. Many of the articles dealing with inflation carry a certain message. For analyzing the rational behavior of consumers it is important to capture the content of those statements. Therefore, we introduce the variable *Tone* to capture the impact of the *tone* channel. Thus the above equation amends to:

$$absGapExp_t = \alpha + \beta Volume_{t-1} + \gamma Tone_{t-1} + \varepsilon_t. \tag{6.2}$$

If $\beta < 0$ the gap between consumers' and professional forecasters' inflation expectations narrows with higher news intensity. Hence, a higher value of the news index brings consumers' expectations closer to rational expectations. By only considering the first specification, Carroll finds that $\beta < 0$. Concerning the contents of reports, a media bias would imply that the coefficient estimate for γ would be significantly different from zero and positive. If $\gamma > 0$ reports about rising inflation would lead to exaggerated fears of consumers relative to professionals. If $\gamma \leqq 0$ the content of news would give information that is consistent with the views of professional forecasters and therefore be unbiased.

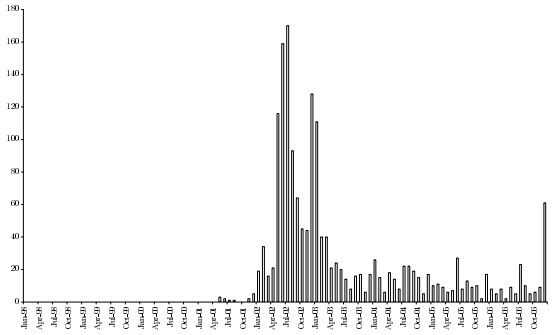
An interesting aspect with respect to the Euro area which was already mentioned in the introduction is the Euro cash changeover and the debate about the inflationary consequences which were attributed to it. Although the Euro cash changeover discussion has not had such strong and visible impact on inflation expectations, as it had on inflation perceptions (Lamla and Rupprecht, 2007a), still an effect might have also been present for inflation expectations.[12] In order to account for that we count the articles dealing with the Euro cash changeover and using the word "Teuro" separately.[13] While the first should capture the discussion of the Euro introduction the second should control for the inflationary fears associated with it by the public. We include both in the analysis because the word "Teuro" contains a judgment on inflationary fears ex-ante, whereas the expression "Euro cash changeover" does not. Both series are depicted in Figure 6.2. The left bar chart represents the amount of articles using the expression "Teuro" within a month, while the right chart counts "Euro cash change". The interesting observation is that while the media coverage of the Euro cash changeover breaks down rapidly in February 2002, the coverage of the

[12] Ehrmann (2006) shows that the gap between perceived and actual inflation widened a lot in Germany during the cash changeover. He finds that the complexity of conversion rates explains the variation in this gap across Euro area countries. Lamla and Rupprecht (2007a) provide evidence that also media reporting play an important role in explaining this discrepancy. Hence, also inflation expectations could be affected by extensive media coverage in that period. Therefore, it seems sensible to discuss how to account for the effects associated with the Euro cash changeover. One obvious way would be to implement dummy variables. With this option one has to decide upon the start and end date of the effect. In order to avoid this possible pitfall we decided to utilize the coverage in the media dealing with the Euro cash changeover. We do this by counting the articles dealing with the Euro cash changeover on the one hand and discussing the price increases using the code word "Teuro" on the other. Obviously, there are various ways to deal with this time frame. While this setup seems to be in line with our media focus we also considered using various dummy variables with different lengths. Even if excluding the rather broad time frame covering 01/2001 until 12/2002 the qualitative results remain.

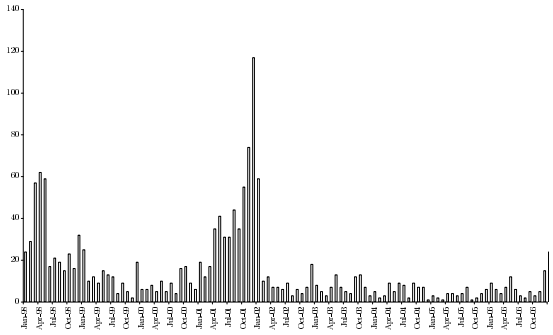
[13] "Teuro" is a concatenation of the words "teuer", the German equivalent for expensive, and the word Euro.

Figure 6.2: Number of Articles Containing "Teuro" respectively "Euroeinführung"

Teuro



Euro Cash Changeover



inflationary consequences begins becoming an important issue in the media. Moreover, it seems to be in the media for about one year on an above average intensity. To control for that effect we estimate a third specification

$$absGapExp_t = \alpha + \beta Volume_{t-1} + \gamma Tone_{t-1} + \delta Euro_{t-1} + \varepsilon_t, \tag{6.3}$$

where $Euro$ specifies either the number of articles containing the expression "Euro cash changeover" or, in a further specification, the word "Teuro".

As expectations are by definition related to future events, it seems sensible to control for those. Hence, we construct the variables *TonePast* and *ToneFor* representing the share of news on inflation with main focus on the the past or being forward looking, i.e. statements on the present and the future. Note, that the time dimension is available since the year 2001. Consequently this yields a fourth specification represented by equation 6.4:

$$\begin{aligned} absGapExp_t = \alpha &+ \beta Volume_{t-1} \\ &+ \gamma_f ToneFor_{t-1} + \gamma_p TonePast_{t-1} + \delta Euro_{t-1} + \varepsilon_t. \end{aligned} \tag{6.4}$$

6.4 Results

The next subsection presents and discusses the estimated coefficients for different specifications. In a second subsection we report estimates of inflation expectations of different groups distinguished by socio-economic characteristics.

6.4.1 The Impact of Media on Aggregate Measures of Inflation Expectations

Table 6.2 contains the coefficient estimates of the regression setup. In column (1) the estimates of equation 6.1 are presented. We can observe that the sign of the coefficient estimate is in line with Carroll's hypothesis, i.e. that more media reporting improves forecast accuracy of consumers. However, the variable is not significant. As a next step we include our *Tone* variable by estimating equation 6.2. Column (2) reveals that the tone increases the gap and hence drives consumers' forecasts away from the rational benchmark. Moreover, the *volume* channels still remains insignificant. This might be due to the fact that for Germany the data include the Euro cash changeover period, where inflation perceptions displayed very unusual patterns.[14] We estimate equation (3) including the articles dealing with "Teuro". For that specification reported in column (3) we observe a significant positive impact of "Teuro". Furthermore the *volume* channel becomes significant and negative, as predicted by theory and in line with Carroll (2003). Thus, it appears to be necessary to control for this "Teuro" debate for the German data. Moreover, this debate exaggerates the inflationary fears and leads to a divergence of inflation expectations from the rational benchmark. This result implies that the two effects of media are also present in the data: on the one hand, higher media coverage helps updating beliefs. On the other hand, if media reports contain a certain opinion or tone, the content is biased and therefore drives a wedge between consumers' and

[14] It is necessary to distinguish between inflation perceptions and inflation expectations here. Both series are published by the European Commission. For the measure of inflation perceptions consumers are asked what they think about price developments in the last 12 months, whereas the question about the expected price movements in the next 12 months serve as the underlying data for the measure of inflation expectations. For example Ehrmann (2006) shows that inflation perceptions are significantly higher than true inflation rates during the Euro cash changeover in Germany. The deviation of inflation perceptions from inflation measured by the Harmonized Index of Consumer Prices (HICP) is also much more visible in the raw data than the deviation of inflation expectations from their benchmark (the professional forecasters' expectations) during the changeover period. Given our results, also inflation expectations reacted on the "Teuro" debate in German media reports, although the effect is weaker for expectations than for perceptions (see Lamla and Rupprecht, 2007).

professional forecasters' expectations. In column (4) we control for the number of articles mentioning "Euro cash changeover" or synonyms. This debate seems to have a similar impact as the *volume* channel and reduces the gap significantly. The difference between the effect of "Teuro" and "Euro cash changeover" is very similar to what we called *volume* and *tone* channel before. The word "Teuro" is a combination of the German words "teuer" denoting expensive and "Euro". Hence, it contains a clear message that claims that the introduction of the Euro caused an increase in prices. Therefore, it is clearly related to the *tone* channel. The word "Euro cash changeover", on the other hand, can be seen as neutral as it does not imply any negative connotation. Furthermore, that word might have attracted consumers to read articles regarding the "Euro cash changeover" and the articles discussing the introduction of the Euro are likely to be associated with terms of price stability and inflation. Hence, the attractiveness of the topic Euro cash changeover has a higher probability to be read by consumers than other articles that discuss inflation, especially as those articles might have been often placed at the title page. This leads to higher frequencies of updating. Hence, the impact is similar to that of the *volume* channel. Also the coefficient is larger in absolute terms, confirming that the articles on the introduction of the Euro have gained more visibility that articles purely on inflation. This variable may also be seen as an instrument variable for our *volume* channel. The Euro cash changeover is an exogenous event, which is associated with currency, but, per definition, does not imply anything for the inflation rate as it is basically only a change in conversion rate. This is especially true if we refer to Figure 6.2. The amount of reporting breaks rapidly down after the cash changeover. Thus, the estimation results based on this explanatory variable reinforce our updating argumentation.

In Column (5) we include both measures and both remain highly significant. As the Euro cash changeover seems to measure qualitatively the same effect as the *volume* channel we discard it from our further analysis and concentrate on the impact of the *tone* channel, the *volume* channel while controlling for the bias generated by the "Teuro" discussion.

As the variable *Volume* contains all press statements we opt to test for the robustness of our results by calculating a variable *VolumeNeut* which excludes statements that contain a certain message about the path of inflation. Despite not statistically significant, the results, presented in column (6), are surprisingly similar to the specification containing the volume reported in column (3). Consequently, this implies that the intensity of inflation reporting triggers an updating of inflation beliefs independent of the message transmitted by the reports.

Next, we test for possible asymmetries between news containing messages on rising respectively falling inflation. There are several studies in behavioral economics that highlight the im-

portance of good and bad news for reactions of financial markets.[15] Thus we separate our *tone* measure into the share of news on rising inflation (*TonePos*) and the share of news on falling inflation (*ToneNeg*). Results are presented in column (7). While both news imply a significant response to the information presented, the response to the number of news on falling inflation implies a stronger effect. News on falling inflation decrease the gap between consumer and professional forecasters' expectations, bringing consumers closer to the rational level. This is what is implied by hypothesis 2a: the message within the report is of high quality and hence further improves consumers' beliefs. On the other hand, news on rising inflation seem to increase the gap between consumers' expectations and the rational benchmark, confirming the hypothesis 2b: in news on rising inflation a media bias exists, as these trigger a widening of the gap between consumers' expectations and the rational benchmark.

An interesting topic is the time dimension. This was neglected in earlier studies. It seems reasonable to assume that people are highly interested in news about future inflation. These news should affect their expectations about future inflation most. One could also argue that present development may have a value added. This may be in line with some kind of adaptive expectations or due to the low quality of news on future inflation. However, there is no doubt that information with respect to the past should be least relevant for forming inflation expectation. In order to disentangle the different time effects we estimate equation (6.4). In column (8) the results is reported. We observe that information with respect to past inflation does not matter. This is not surprising as, obviously, information and news on present and future inflation should be the more relevant for forming inflation expectations. Therefore, coefficient of *ToneFor* is highly significant and about four time higher.

Overall, our results support the results of Carroll (2003) that indeed more news lead to more updating and information processing which finally transmits into better inflation forecasts. Going two steps further we can highlight that, contrary to the positive impact of the amount of news, the specific content of news drives away expectations from the rational benchmark. This media bias is mainly driven by news on rising inflation, which consumer expectations react more to than rational forecasters. Finally, consumers deduct most implication from present events.

[15] Especially, bad news in good times seem to matter most. See for instance Andersen et al. (2003).

Table 6.2: Regression with Newey-West Standard Errors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Volume	-0.704	-0.596	-1.001*	0.024	-0.512		-0.970*	-0.881*
	(0.630)	(0.589)	(0.552)	(0.560)	(0.475)		(0.532)	(0.478)
Tone		0.934***	1.237***	0.835***	1.128***	1.192***		
		(0.314)	(0.230)	(0.290)	(0.242)	(0.236)		
Teuro			2.172***		1.891***	2.098***	2.146***	1.321**
			(0.523)		(0.550)	(0.491)	(0.537)	(0.537)
ToneFor								0.801**
								(0.372)
TonePast								0.173
								(0.201)
TonePos							0.908*	
							(0.501)	
ToneNeg							-1.665***	
							(0.519)	
VolumeNeut						-0.605		
						(0.432)		
EuroCashChangeover				-2.144***	-1.508***			
				(0.480)	(0.399)			
Constant	2.716***	2.536***	2.413***	2.560***	2.446***	2.195***	2.611***	2.757***
	(0.304)	(0.272)	(0.270)	(0.261)	(0.268)	(0.217)	(0.432)	(0.244)
Obs	94	94	94	94	94	94	94	68

Robust standard errors in parenthesis; ***/**/* denote the 1/5/10%-significance level

Table 6.3: Results Socioeconomic Characteristics with Newey-West Standard Errors

	Gender		**Age**				**Education**			**Income**				
	female	male	65+	50–64	30–49	16–29	further	secondary	primary	4Q	3Q	2Q	1Q	average
Volume	-1.008*	-0.945*	-0.895	-0.796	-1.101**	-0.872	-0.643	-0.851*	-1.086*	-0.874	-0.805	-0.504	-0.863*	-0.955*
	(0.526)	(0.546)	(0.598)	(0.557)	(0.538)	(0.546)	(0.508)	(0.469)	(0.637)	(0.580)	(0.604)	(0.532)	(0.492)	(0.540)
TonePos	0.939*	0.910*	1.169**	0.669	1.032**	0.827*	0.965*	0.737	1.121**	1.023**	0.776	0.883*	0.861*	0.896*
	(0.497)	(0.504)	(0.561)	(0.503)	(0.519)	(0.476)	(0.502)	(0.463)	(0.552)	(0.498)	(0.557)	(0.471)	(0.480)	(0.500)
ToneNeg	-1.696***	-1.633***	-1.315**	-1.665***	-1.713***	-1.859***	-1.064*	-1.734***	-1.678***	-1.623***	-1.587**	-1.292**	-1.400**	-1.691***
	(0.528)	(0.543)	(0.627)	(0.505)	(0.569)	(0.486)	(0.588)	(0.491)	(0.580)	(0.523)	(0.609)	(0.608)	(0.536)	(0.534)
Teuro	2.184***	2.125***	1.947***	1.930***	2.180***	2.273***	1.977***	2.119***	2.194***	2.466***	1.909***	1.983***	1.897***	2.148***
	(0.524)	(0.552)	(0.562)	(0.524)	(0.556)	(0.534)	(0.509)	(0.537)	(0.555)	(0.544)	(0.623)	(0.481)	(0.558)	(0.539)
Constant	2.678***	2.549***	2.323***	2.590***	2.697***	2.816***	2.612***	2.694***	2.529***	2.525***	2.437***	2.402***	2.355***	2.614***
	(0.426)	(0.433)	(0.482)	(0.431)	(0.445)	(0.390)	(0.422)	(0.398)	(0.479)	(0.432)	(0.483)	(0.421)	(0.429)	(0.431)
Obs	94	94	94	94	94	94	94	94	94	94	94	94	94	94

Robust standard errors in parenthesis; ***/**/* denote the 1/5/10%-significance level

6.4.2 The Impact of Media on Different Socioeconomic Groups

Several recent studies show that socioeconomic attributes explain patterns in economic behavior. Berger et al. (2007) provide evidence that males and females hold significantly different opinions regarding ECB's monetary policy performance. Inoue et al. (2006) show that the response in consumer surveys to news on inflation increases with the level of education. On the other hand, Aucremanne et al. (2007) provide evidence that the reaction between those socioeconomic groups was fairly similar during the cash changeover. In an commentary on the demographics of inflation opinion surveys in the U.S., Bryan and Venkatu (2001) point out that the data exhibit a large disparity in inflation estimates of different types of people. They note that young respondents have been found to overestimate inflation. The same is true for low educated people and women. They also controlled for the impact of ethnicity. Overall they find low variability in their data set which points to a systematic different perception within each socioeconomic group.

We have data for different dimensions of the socioeconomic characteristics of the survey participants (income level, age, education level, profession and sex). Data are taken from the EU Consumer Survey. We replicate the regressions in Table 1 for our preferred specification in column (7) including *tone*, *volume* of news and the variable for the Euro cash changeover period capturing the "Teuro" debate. Also the other specifications are fairly robust to splitting the consumer expectations sample in different groups, but are for the sake of brevity not reported here.[16] Results are presented in Table 6.3. Notably, the main results do not change when differentiating consumer survey inflation expectations data by socioeconomic factors. Above that, we can see that the coefficients for all socioeconomic characteristics vary. However, judging on statistically different responses becomes difficult as the standard errors are quite high and thus tests of equality conditional of identical samples show no significant differences. Nevertheless, while keeping this in mind we still can draw some tentative conclusions. While the systematic bias captured in the constant are fairly the same in all specification, the reaction to the tone, the Teuro bias as well as the volume seems to differ.

We can observe only very small difference in the reaction between male and female in all dimensions. Thus, the impact of media does not appear to depend on gender. With respect to age older people are less prone to a bias than younger people. Maybe some learning takes places and some experiences materializes, or as wealth grows with age the marginal costs of inflation increase and the marginal gain of investing in information of inflation rises. Our estimations also indicate

[16] All other results are available upon request.

that higher educated people are less subject to a media bias induced by the content of the message. Both, news on rising or falling inflation are incorporated with a higher efficiency. Moreover, they are less affected by the "Teuro" debate. This makes intuitively sense. Well-educated persons are more likely aware of the bias and thus respond less. They are also likely to be more interested in the business and economics sections of newspapers, or buy newspapers or watch news that cover economic topics. Studies highlight that less educated people spend more time watching television and therefore may be more prone to some hysteresis induced by the media. Turning to the income quartiles the following picture emerges. The higher the income the stronger people's inflation expectations respond to news about inflation transmitted in media reports. In addition, as the Teuro coefficients clearly shows, they are prone to media induced hypes and topical inflationary fears. As income is on average a function of education, the effects of income and education should be interrelated and pointing to the same direction. This is, however, only partly true in our estimated results. While education works through immunization with respect to the media bias, rising income induces a better updating of the expectation beliefs due to incoming information.

6.4.3 Robustness

Finally, we would like to address some general issues with respect to endogeneity and causality. One could argue that news are partly demand driven, which implies that newspapers are biased towards consumers' prior opinions (e.g. Gentzkow and Shapiro 2006a/b).

Nevertheless, there are some good reasons to believe that this issue does not play a crucial role in our setup chosen. First, the media indicators are employed with a one period lag, i.e. we use data covering news of the preceding month relative to the questionnaire that establishes the inflation expectations. Thus, per definition, news of the last period cannot be demanded by expectations today. This would only be the case if expectations are highly persistent, which is not the case.

Second, our dependent variable is the gap between consumers and professionals. Endogeneity would be present if consumers' demand would be distinct from the demand of professional forecasters. If we assume that consumers and professionals demand news equally this would not be an issue. Put differently, endogeneity would exist if news companies would, for instance, only focus on the demand of consumers.

Third, as discussed earlier, the Euro cash changeover variable seems a sensible instrument for the *volume* channel. The demand is driven by an exogenous event not directly linked with

movements in prices and inflation, but at the same time is related to topics like price stability and inflation. The results including this variable reinforce our statements.

One final exercise underlines the robustness of our results. A widely acknowledged way to deal with endogeneity issues as well as to investigate whether a specific notion of causality is present, is to employ vector autoregressions (VAR). Following this path, we also intend to tackle concerns with respect to the estimation setup using the Newey-West correction for autocorrelation. For this purpose we set up a system consisting of the variables *Tone*, *Volume* and *absGapExp*. In addition, in order to control for real shocks to inflation we introduce real-time figures of the Harmonized Index of Consumer Prices (HICP) for Germany. If media just report what is happening in the real world, this would imply that no extra effect of media would be present. Figure 6.4.3 depicts the graphs of the impulse responses to specific shocks.[17] We observe that HICP significantly affects the gap as well as the *tone* channel and the *volume* channel. These results correspond with our ex-ante expectations. If figures about rising inflation are released, it is likely that this real shock is picked up by media companies leading to more reports dealing with news about rising inflation. Thus media partly mirror real events. Notably, the effect on the *volume* channel evaporates rapidly. In addition, as indicated by the widening of the gap, people seem to overreact to changes in the HICP. In contrast to the reaction to HICP shocks in the media this impact is much more persistent. Concerning our key variables, this exercise reinforces our earlier statements.

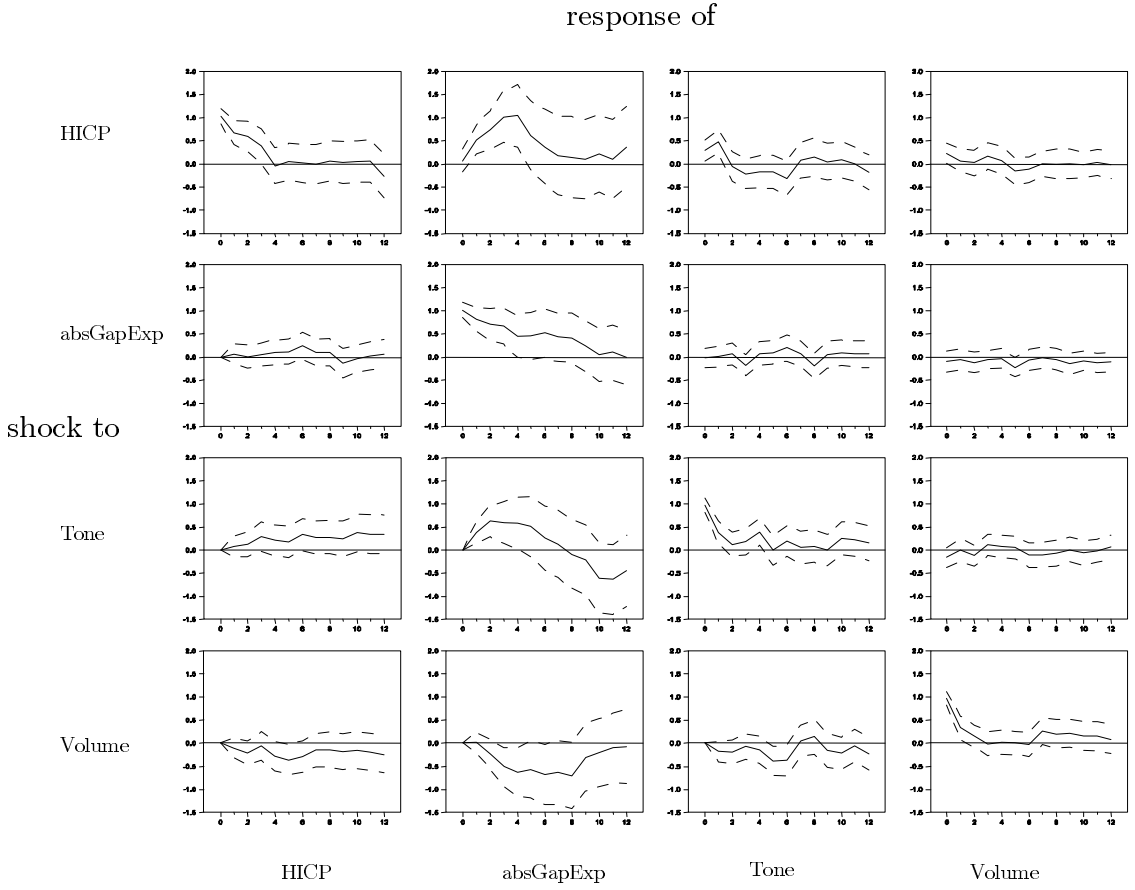
A shock in the *tone* channel increases the gap while a shock in the *volume* channel reduces the gap. Finally and most importantly, there is no evidence that changes in the gap drive the *tone* and *volume* channel. Thus we can conclude that, even controlling for actual inflation, the *tone* as well as the *volume* channel significantly and robustly drive the gap between consumers and producers.

6.5 Conclusions

In this chapter we identify two channels via which media influence consumers' inflation expectations. On the one hand, the *quantity* of media reports matters. A higher intensity of reporting makes consumers more likely to pick up news on inflation, induces an update of their expectations and brings them closer to the full information rational forecast. This is what we call the *volume* channel. On the other hand, the *quality* of reporting matters. Media reports often contain an opin-

[17] We estimated several VAR systems using various length selection criteria and orderings. However, the qualitative results remain unchanged.

Figure 6.3: Vector Autoregression – HICP, absGapExp, Tone, Volume



Dashed lines represent confidence intervals of two standard deviations.

ion or a tone, which is then taken up by consumers. This is what we denote as the *tone* channel. If the information transmitted by the media has a high quality, consuming the reports brings consumers' inflation expectation closer to the rational forecast. If, however, media reports are biased, i.e. if they transmit exaggerated or incomplete information, consuming these reports distorts the accuracy of forecasts.

We provide evidence that both channels play a role. Overall, our results support the view of Carroll (2003) that indeed more news lead to more updating and information processing which finally eventuates in a better inflation forecasts. Furthermore, we highlight that, contrary to the positive impact of the amount of news, the specific content of news drives away consumer expectations from the rational benchmark. In addition, socioeconomic factors to some extent appear to influence the reaction to media. Educated and older people are less exposed to the media bias. Moreover, our results indicate the special role of the Euro cash changeover. Especially, the "Teuro" debate has significantly increased the gap. Finally, the content of news matters with respect to the time horizon it addresses: the inflation reports that transmit a message related to the past inflation do not significantly affect expectations, whereas reports dealing with present and future inflation matter for consumers' expectations. Our results remain even when controlling for possible endogeneity issues as well as shocks in real inflation figures.

Our findings have important implications for the discussions on modelling expectation formation, the role of media agencies and the assumptions on rationality of consumers' economic behavior: media can have the power to bias consumers' expectations. Such biases could ultimately lead to real adjustments. Hence, for understanding expectation formation and inflation dynamics, the role of media and the failure to digest the optimal amount of information should clearly be taken into account.

CHAPTER 7

Conclusion

As mentioned in the introduction this dissertation sheds light on the way news are digested and incorporated into expectations. While most attempts are made from a theoretical perspective we add empirical evidence. We exemplify the impact of news on expectations considering different economic areas.

7.1 Expectations and Monetary Policy

In the first part of this dissertation, comprising the Chapters 2, 3 and 4, we show that news with respect to the current standing and the future path of monetary policy, as communicated by the ECB, are of major importance for market participants. While this result has been established already in earlier studies, we can add important qualifications using a sound methodological approach.

Chapter 2 analyzes the impact of ECB communication on interest rates at different maturities and shows that ECB communication affects medium- to long-run expectations. We, furthermore, highlight the importance of news on price developments. Finally, we find that communication becomes less important if inflation is outside its target range. Chapter 3 uses a high-frequency exchange rate data embedded in a FIGARCH approach. This approach allows us to track the response of communication in a timely fashion avoiding identification problems. We confirm findings

of Chapter 2 with respect to the importance of news on prices as well as the conditionality of communication regarding inflation. In addition, we elaborate that the different communication devices are complementary. While positive interest rate surprises are to some extent self explanatory, the response to negative interest rate surprises is partly delayed to the point in time where the introductory statement is made public and the decision is explained in more detail. Moreover, we provide evidence that the communication channel gained importance. Finally, Chapter 4 uses a novel and distinct way to measure expectations building. It considers how the content of ECB announcements was perceived and transmitted by the media. Concerning the results it confirms the inference that developments in prices are of vital importance. In addition, it makes further qualifications: communication is more effective if uncertainty is low, if we are at the beginning of an inertia dynamic and if inflation is moderate.

Overall, we can draw some general conclusions. First, using different content based indicators, different ways to capture expectations of market participants and different econometric setups we provide evidence that especially news concerning price developments are of major importance. Second, the importance of communication is conditional on the current policy and economic stance.

The value added lies not only in the results presented above but also in the way they are derived. While the impact of ECB communication on markets has been reported in earlier studies, our approach allows us to tackle some methodological drawbacks of earlier work implying a solid fundament for our inferences. First, we employed content based indicators which, as we believe, are able to monitor the communication more accurately than the often utilized way of counting signal words. Second, switching to higher frequency data bypasses identification problems as we can exactly track the response to the communication and the interest rate announcement. Finally, we introduce a new way to capture expectations utilizing the opinion catered by the media which is not subject to short-term market hysteresis.

7.2 Media, News and the Economy

Notably, central banking is not the only economic area where news are digested and incorporated into expectations. The second part of this dissertation provides evidence that restrictions in information acquisition and processing may explain formation of inflation expectations as well as business cycle comovements. In this context we highlight the role of media as a provider of timely and cheap information.

In Chapter 5 we show that excess comovement in business cycles is partly driven by information restrictions. Following the line of argumentation by Veldkamp and Wolfers (2007) we find that information stemming from media articles substantially affects firms' perceptions and expectations. Moreover, economy-wide news have a significant and more pronounced impact on firms' expectations and perceptions than sector-specific news. As most timely and reliable information is provided on a economy-wide level, companies use this information to infer movements in sector-specific figures. This consequently implies that companies react more similarly to shocks than they would do in an economy without information restrictions. Notably, this effect differs between sectors. The discrepancy might be reasoned by the reliance on sector-specific information. Companies with a lower correlation with the economy, higher growth rates and greater volatility have stronger incentives to buy and accumulate sector-specific information.

In Chapter 6 we find that media statements dealing with inflation affect the precision of consumers' inflation forecasts. Two dimensions can be identified to drive the gap between consumers' forecasts and the best possible alternative, represented by the forecast of professional analysts. First, the volume of news matters as more reporting raises the attention to a specific topic and triggers an updating of beliefs. Second, the content is important as the public could potentially infer the correct inflation forecast from the media. However, we find that the, as we call it, tone channel induces a bias and deteriorates beliefs. This implies that media agencies tend to exaggerate certain developments associated with prices and people adopt these views. Furthermore, we can show that the impact of both channels varies with the socioeconomic characteristics of the respondents. Older and more educated people are less prone to a media bias. While the volume channel has been identified by earlier studies we are the first to address the impact of the tone channel as well as to make statements on the dependency on socioeconomic factors.

7.3 Final Remarks

Summing up, we add to the scarce empirical literature on the way expectations are formed in different economic areas. With respect to monetary policy we can enrich the fast growing literature on the relevance of central bank communication in two dimensions. First, we follow a sound way in modelling communication and expectations as well as estimating this relationship. Second, we can make further qualifications. Notably, dealing with a "young" central bank our sample is relatively small. This should be always kept in mind when referring to our results. Concerning future research,

the challenge remains in appropriately capturing communication of the ECB and the expectations of market participants. Timely collected survey polls would certainly add to the literature. In addition, collecting results from other central banks following different communication strategies, e.g. being less or more transparent, is necessary to distill the best way of interaction between the public and the central bank.

With respect to the second part of the dissertation we highlight the importance of restrictions in information acquisition and processing. This has not been addressed so far in the empirical macroeconomic literature. We emphasize the role of media as a provider of timely and cheap information and motivate that information restrictions force economic agents to rely on rather general sources. This, as we show, affects expectations formation and most likely economic outcomes. The latter is clearly the challenge for future research. So far we do not provide evidence that the impact of media, say for instance the tone channel, leads to a bias in real decision making. The same applies for the impact of firms' expectations.

While we made substantial progress with this dissertation, the impact of news on expectations formation remains a clear under-researched area needed to be explored in the upcoming years thoroughly.

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